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Strength Decrement of Muscles of Trunk and Lower Extremities from Sub-Maximal Treadmill Running[1]

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Abstract

The purpose of this study was to examine the strength-decrement fatigue effects in 14 muscle groups of the trunk and lower extremities resulting from a sub-maximal treadmill run at seven miles per hour for a period of ten minutes on a horizontal plane. Only two muscle groups, the hip outward rotators and the trunk flexors, were fatigued sufficiently to cause a significant strength decrement; a third muscle group, the knee flexors, had a loss in mean strength which approached the .05 level of confidence.

THE BASIC concept of strength decrement is that a reduction in the level of tension development of a muscle after use indicates fatigue. A demonstration of this effect on the elbow flexor muscles has been reported by Clarke (2). These muscles were fatigued to exhaustion by continuous exercise on the Kelso-Hellebrandt ergograph with a weight load equal to three-eighths of each subject's elbow flexion strength and with a cadence of two seconds for each flexion and extension. The initial drop in strength, 30 seconds after exercise, was approximately 32 per cent; the strength loss was still approximately 13 percent at 7½ minutes, 10 per cent at 17½ minutes, and 4 per cent at 45 minutes after exercise.

The strength decrements from carrying various army packs on military marches of 7.5 miles were determined by Clarke, Shay, and Mathews (3). Muscle groups tested before, during, and after the march were those under direct stress in supporting the packs, those involved in stabilizing the rest of the body in relation to the pack, and those primarily needed in marching. Differentiation of muscle fatigue patterns resulting from carrying different packs of varying weights and positions on the body was possible with the strength decrement procedure. Similar results were obtained in determining the fatigue effects on the lower leg and foot muscles from wearing various boots and shoes on pack-carrying marches (4). Davis (5) also studied the strength decrements of six muscle groups in swimming 200 yards for time. The greatest mean loss of strength for 30 swimmers was 22 per cent for the shoulder extensor muscles.

The purpose of the present study was to examine the fatigue effects (strength decrement) in muscles of the trunk and lower extremities result-

[1]Appreciation is expressed to the Graduate School, University of Oregon, for subsidizing this study; and to the following graduate students for assistance in collecting and treating the test data: Gavin H. Carter, L. Richard Gëser, Frank Kennedy, Campbell Snowberger, and Thomas D. Winbigler.

ing from a sub-maximal run on a treadmill. Fourteen muscle groups were included, as follows: trunk flexors and extensors; hip flexors, extensors, abductors, adductors, inward rotators, and outward rotators; knee flexors and extensors; and ankle dorsi flexors, plantar flexors, inverters, and everters.

Research Procedures

SUBJECTS

Test data were collected on non-disabled University of Oregon male students enrolled in non-professional physical education classes. Strength decrements were obtained on 17 subjects for each of the 14 muscle groups following a standardized sub-maximal treadmill run. Thus, 238 different subjects participated in the study.

TRAINING OF TESTERS

Testers were carefully trained in cable-tension strength testing techniques before they were permitted to collect test data. In this process, first, the testers were instructed in the techniques of testing and were permitted to practice on available subjects; and, next, the testers administered each of the 14 tests twice to the same subjects, continuing until 30 consecutive subjects were tested and satisfactory objectivity coefficients obtained. Approximately ten weeks were necessary to thus qualify the testers. The objectivity coefficients finally obtained ranged from 0.87 to 0.98; these compared well with the original objectivity coefficients reported for these strength tests.

TREADMILL PROCEDURES

Pre-exercise and post-exercise measurements of strength were necessary to determine the strength decrement from treadmill running. The procedures were as follows:

1. The techniques for administering the 14 cable-tension strength tests were those described by Clarke (1). The strength decrement of only one muscle group was tested on each treatmill run, to provide uniform recovery time.

2. The pre-exercise strength measurement was taken after the subject had run on the treadmill for one minute. This preliminary run allowed him to become familiar with the treadmill, as only subjects untrained in treadmill running were used; and it also permitted a short warm-up before initial testing.

3. The specified run on the treadmill was at seven miles per hour for a period of ten minutes on a horizontal plane (or 0 grade). These conditions were selected as sub-maximal but were strenuous enough to allow all of the subjects to complete the run and be in a moderate to a high state of fatigue. This determination was based on several trial runs at various speeds and distances by laboratory personnel and random volunteers. Subjects who were unable to complete the specified run were eliminated from the study.

4. The post-exercise strength test was administered one minute after completion of the treadmill run. This interval permitted the subject to leave the treadmill and to be prepared for testing. A standardized interval was neces-

sary to control the length of time for strength recovery. In ergographic studies, Clarke (2) showed that initial recovery of the elbow flexor muscles following exhaustive exercise was rapid. Control of recovery time was essential in comparing the various strength decrements.

STATISTICAL TREATMENT

Comparison of the mean strength of the subjects following exercise was made with the pre-exercise mean for each muscle group included in the study. The significance of the differences between means was tested by the *t* ratio. Inasmuch as the study was in the nature of a one-group experiment, as each subject's pre- and post-exercise scores were compared, the *t*-ratio formula utilized was for correlated groups (7).

For 17 subjects, *t* values of 1.75 and 2.58 denote significance at the .05 and .01 levels of confidence respectively (6). These values for *t* were chosen because significance was measured from zero, or no diffrence, in a positive direction only. In explanation, when the hypothesis tested postulates difference in one direction only, the probability yielded by *t* as given in ordinary tables may be halved.

Results

The results of this research appear in Table 1. Appropriate interpretations of these results are as follows:

TABLE 1

Pre- and Post-Exercise Means with Mean Differences, Standard Errors of the Differences and t-Ratios for 14 Cable-Tension Strength Tests

Test	M1*	M2**	Md	σd	t-ratio
1. Trunk flexion	133.41	124.17	−9.25	3.09	2.99
2. Trunk extension	111.44	113.68	2.25	6.22	.36
3. Hip flexion	150.79	153.55	2.75	.81	.90
4. Hip extension	128.25	132.23	3.98	4.25	.94
5. Hip abduction	149.01	147.96	−1.05	2.73	.38
6. Hip adduction	114.90	114.59	− .31	1.19	.26
7. Hip inward rotation	30.52	29.37	−1.15	1.53	.76
8. Hip outward rotation	47.03	43.74	−3.29	.91	3.61
9. Knee flexion	163.91	158.04	−5.87	4.03	1.46
10. Knee extension	272.06	265.00	−7.06	8.28	.85
11. Ankle inversion	30.78	29.94	− .84	.77	1.09
12. Ankle eversion	63.09	65.29	2.21	1.90	1.17
13. Ankle dorsi flexion	91.25	91.73	.48	3.50	.14
14. Ankle plantar flexion	374.90	372.90	−1.28	8.99	.14

*Pre-exercise mean.
**Post-exercise mean.

1. The highest *t's* were 3.61 and 2.99, obtained for strength decrements of the hip outward rotator and trunk flexor muscles respectively; these drops were significant beyond the .01 level of confidence. Thus, these muscle groups

showed the greatest muscular fatigue as a result of the prescribed treadmill run.

2. The t of 1.46 for knee flexor strength decrement approached, but did not reach, the .05 level of confidence. The strength loss of the ankle inverter muscles resulted in a t of 1.09, which is appreciable but not statistically significant.

3. Of the other muscle groups, five showed decrements with t's below 1.00, namely: knee extensors (.85), hip inward rotators (.76), hip abductors (.38), hip adductors (.26), and ankle planar flexors (.14). None of these, of course, is statistically significant.

4. The balance of the muscle groups showed an increase in mean strength following the treadmill run. These groups with t's were as follows: ankle everters (1.17), hip extensors (.94), hip flexors (.90), trunk extensors (.36), and ankle dorsi flexors (.14). These increments are not statistically significant.

Discussion

In considering the results of this study, several factors seem pertinent as follows:

The treadmill run was definitely sub-maximal in dosage. All of the subjects were able to complete the prescribed run of seven miles per hour for ten minutes on a horizontal surface without reaching a state of exhaustion.

Inasmuch as the treadmill run was set at a prescribed speed and length of time, the fatigue effects on the different subjects depended on their level of physical condition. Some subjects completed the run easily while others were under obvious stress at the end. Thus, the strength decrement effect varied from subject to subject; it was not fairly constant as found in the all-out swimming efforts reported by Davis.

Muscular exertion on the treadmill was observed as somewhat different from a similar performance on the track. In treadmill running, the major muscular requirement is in carrying the foot forward for each stride; the action of the rotating belt carried it to the rear without requiring the push-off and propulsion forces necessary in ordinary running.

Only 17 subjects were used to determine strength change for each of the 14 muscle groups. As a consequence, the standard errors of the differences between pre- and post-exercise means were relatively large; thus, the differences must be pronounced in order to obtain significant t's. Several of the t's for strength losses were fairly large; the strength loss of these muscle groups might well be investigated further with a larger number of subjects.

While the increases in strength following the treadmill run were not statistically significant, continued study of this potential phenomenon is desirable. Quite possibly a warm-up effect of muscles not involved in the run may account for this result. While some warm-up was required before the run, it may not have been sufficient for this purpose.

Conclusion

As a result of this sub-maximal run on the treadmill, only two muscle groups, the hip outward rotators and the trunk flexors, were fatigued sufficiently to cause significant decrement. A third muscle group, the knee flexors, had a loss in mean strength which approached but did not reach the .05 level of confidence. Of the other muscle groups, five showed statistically insignificant strength losses; and five resulted in statistically insignificant strength gains, although the *t* denoting the degree of increase in mean strength of the ankle inverters reached 1.17.

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Factorial Analysis of Motor Co-ordination Variables for Third and Fourth Grade Girls

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Abstract

The problem of what factors are present in variables which have been used in the past to measure some phase of motor co-ordination was investigated further. Ninety-two third and fourth grade girls were used in this study. The multiple-group method of factoring was used to extract nine factors. Names were given to four of the factors: balancing objects, speed of change of direction of arms and hands, total body quick change of direction, and body balance. A fifth factor was tentatively identified as a vertical total body quick change of direction. Two of the factors (balancing objects and speed of change of direction of arms and hands) are similar to factors identified in a former study in which college women were used for the sample. Similarities and differences between the two studies were discussed. This comparison suggested that a different definition of motor co-ordination for different age levels should be considered.

"A FACTORIAL Analysis of Motor Co-ordination" (1) has been reported previously. The initial study used a sample of college women and was undertaken in an effort to demonstrate what was actually being measured by a diversified group of tests which claimed to measure the same complex concept. While this study did not give a final answer to "what is motor co-ordination," several factors were identified and suggestions were given for possible further studies. Follow-up studies using different age levels and the two sexes might give valuable information about the possibility of using the same operational definition of motor co-ordination for all age levels. Perhaps the definition of motor co-ordination should be altered for different age levels. Such would be indicated if the same variables group differently with another age level. A comparison of factors of motor co-ordination at the various age levels should help in further understanding individual differences. Certainly, such comparisons would indicate other research which would help in refining an operational definition of motor co-ordination, in diagnosing strengths and weaknesses in performance, and in designing studies to see if instruction could noticeably alter performance of weaknesses.

The Problem

The problem of what factors are present in variables which have been used in the past as some measure of motor co-ordination is to be investigated

further. It shall be the purpose of this paper to discuss the follow-up study using third and fourth grade girls as a sample. Certain similarities and differences between the analysis made of third and fourth grade girls and college women will be made.

Procedure

The same, or modified, tests[1] administered to college women were given to 92 third and fourth grade girls. The initial study with college women indicated that clearer identity might be possible if two more tests were included; another total body tempo (8b) and another total body quick change of direction item (14b).[2] A total of 23 tests were given. One tempo test (Item 6 —Tempo, long-short) was eliminated because the method of recording scores was not uniform for all subjects. All tests were administered a second time in order that test re-test reliabilities could be estimated. The second administration of each test was no more than five days after the first testing. Purposely the activities were not included in the regular physical education classes between the two testings.

Test re-test correlations were computed on the various possibilities of scoring the trials in each test.[3] The method of scoring which gave the highest coefficient of correlation was used to compute Pearson Product Moment correlations. These coefficients of correlation were calculated on punched-card equipment by the Computing Service of the University of Wisconsin. The original correlation matrix of 231 intercorrelations may be found in Table 1. Procedures for the multiple group method of factoring, as well as the outline of a technique for rotating the initial oblique solution to the primary solution as given by C. W. Harris and Schmid (2), were followed.

All 92 subjects had 20/20 vision, but were not checked on the Keystone Telebinocular as were the college women.

Discussion of Data

Table 1 gives the intercorrelations of the 22 tests, as well as the residuals. As may be seen, much specificity is present in the intercorrelation matrix. This would lead one to believe that perhaps more factors were present than in the sample using college women. The extraction of 9 factors reduced the present intercorrelation matrix essentially to zero. Eight factors reduced the college sample intercorrelation matrix.

Interpretation of Factors.[4] Table 2, the Oblique Factor Matrix, and Table 3, the Intercorrelation of Factors Matrix, will be used to discuss the nine factors extracted.

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[1]See Table 2 for the list of tests.

[2]Numbers have been left as in the initial study to facilitate comparisons.

[3]See Table 2 for reliability estimates and method of scoring used.

[4]Children at this age level could not follow the directions of repeating an activity in the same tempo as set in the first trial. The tempo items administered to the third and fourth grade girls actually became tests to see how rapidly the activities could be done. Hence, all tempo items in this study must be interpreted as speed of movement items.

TABLE 1

Original Correlation Matrix (r) and Residuals[1]

	1	2	3	4	5	7	8a	8b	9	10	11	12	13	14a	14b	15	16	17	18	19	20	21
1		*015*	*—014*	*—059*	*089*	*—050*	*002*	*—002*	*—016*	*—022*	*068*	*—018*	*—035*	*035*	*—056*	*018*	*—017*	*—049*	*048*	*018*	*—018*	*—033*
2	129		*—012*	*056*	*—011*	*—066*	*—039*	*039*	*—014*	*—057*	*058*	*008*	*015*	*—015*	*042*	*086*	*—001*	*—059*	*—026*	*014*	*—014*	*—031*
3	017	492		*—056*	***011***	***066***	*039*	*—039*	***014***	***057***	*—058*	*—008*	*—016*	*015*	*—042*	*—086*	*001*	*059*	*026*	*—065*	*065*	*031*
4	—009	046	055		*—017*	*—013*	*—008*	*008*	*059*	*—041*	*062*	*—050*	*—057*	*058*	*007*	*056*	*—027*	*—074*	*045*	*012*	*—012*	*010*
5	289	—026	088	087		*—035*	*027*	*—027*	*—089*	***—083***	*028*	*007*	*—051*	*051*	***018***	*023*	*—014*	*062*	*—070*	*—025*	*025*	*—012*
7	—003	026	178	127	—054		*014*	*—014*	*050*	*—027*	*—039*	*—026*	*—018*	*018*	*—046*	*018*	*045*	*—034*	*—030*	*—062*	*062*	*081*
8a	011	230	364	—141	207	—150		*045*	*—002*	*017*	*—020*	*006*	*—030*	*030*	*—009*	*—023*	*026*	*039*	*—043*	*—078*	*077*	*—018*
8b	152	459	336	—071	017	—113	436		*002*	*—017*	*020*	*—006*	*047*	*—047*	*009*	*023*	*—026*	*—039*	*042*	*042*	*—042*	*018*
9	301	—023	146	334	186	181	—037	005		*022*	*—068*	*018*	*035*	*—035*	*056*	*—018*	*017*	*049*	*—048*	*—018*	*018*	*033*
10	031	—005	231	285	194	171	—055	—030	301		*004*	*023*	*011*	*—011*	*—049*	*—018*	*024*	*—004*	*—002*	*—006*	*006*	*—034*
11	149	147	091	133	020	360	—060	092	139	191		*003*	*—048*	*048*	*—028*	*034*	*—046*	*000*	***012***	*058*	*—058*	*—001*
12	177	124	131	049	061	406	—116	110	295	230	615		*066*	*—066*	*073*	*—052*	*001*	*033*	*019*	*030*	*—030*	*—081*
13	071	—027	127	173	217	052	—057	—081	476	242	121	260		*—021*	*072*	*—003*	*013*	*042*	*—051*	*026*	*—026*	*—021*
14a	024	—258	—099	101	313	—079	006	—314	142	015	—008	—089	382		*—072*	*003*	*—013*	*—042*	*051*	*—033*	*033*	*021*
14b	007	100	108	212	346	—003	105	—003	200	135	005	088	284	082		*—016*	*023*	*022*	*—028*	*—023*	*023*	*—025*
15	193	037	—027	267	204	080	062	172	262	174	271	226	261	141	108		*019*	*029*	*—047*	*016*	*—016*	*—006*
16	075	010	062	120	—056	086	054	034	156	148	259	231	257	094	062	484		*034*	*005*	*—008*	*008*	*—009*
17	167	—016	027	091	115	001	—086	—061	159	096	048	124	141	—011	128	232	325		*015*	*034*	*—034*	*—083*
18	181	—144	—005	248	134	034	—004	023	176	174	241	172	143	148	184	306	339	210		*040*	*—040*	*098*
19	130	043	—103	—180	151	—361	075	172	—074	—219	—385	—210	046	202	—067	009	—168	007	—172		***—014***	***048***
20	095	—015	068	—056	249	—118	155	069	086	—064	—402	—121	101	276	033	093	—119	—052	—196	604		*—048*
21	066	215	237	—069	208	122	195	203	—030	—054	113	063	063	119	164	073	073	001	148	183	073	

[1]Residuals are in italics. Decimal points have been omitted.

TABLE 2
Oblique Factor Matrix—V[1]

Variable	A	B	C	D	E	F	G	H	I	h_j^2	Rel. Est.	Method of Scoring
1. 30-sec. rod balance	063	050	156	—011	134	—069	—001	188	*491*	405	837	Best 2 of 3
2. 30-sec. rod balance, replacement	*533*	073	063	—012	035	—085	—038	036	067	576	750	Sum of 3
3. 2 rod balance, replacement	*437*	066	—003	166	—040	088	098	—062	—067	580	885	Best of 3
4. Dynamic balance	089	—091	032	—069	222	*455*	—060	069	—073	402	882	Best of 3
5. Static balance	—066	005	098	184	—099	*254*	112	*430*	134	487	883	Best of 3
7. Tempo-arm exercise	019	*432*	068	—077	—066	101	—098	042	—042	356	921	Best 2 of 5
8a. Tempo-total body	080	—082	—057	200	—054	005	*431*	054	—038	529	872	Sum of 5
8b. Tempo-total body	133	178	*271*	—091	107	043	*358*	—035	039	550	842	Sum of 5
9. Crosses and vertical lines	—066	006	—039	*297*	—069	092	057	—098	*447*	654	852	Best of 2
10. Nose and ear	072	064	020	006	096	*353*	—011	040	—057	304	742	Sum of 3
11. Stick placing	—025	*588*	—087	*169*	026	—087	*192*	—031	000	684	704	Sum of 2
12. Block tapping	—032	*730*	*269*	061	041	—008	093	—011	042	698	995	Sum of 3
13. Burpee	133	021	—034	*493*	035	054	022	—045	067	544	915	Best of 3
14a. Short potato race	—019	—035	039	*438*	—016	—021	—019	065	—067	510	821	Best 2 of 3
14b. Criss-cross	145	—088	—063	090	051	*330*	004	*428*	—057	352	858	Sum of 3
15. Soccer kick—distance	—094	*220*	*322*	097	*503*	*293*	*453*	006	—088	550	735	Sum of 5
16. Basketball throw—distance	*201*	090	034	*208*	*688*	—023	*341*	—096	—094	658	902	Sum of 5
17. Ball catching	*265*	—074	097	—089	*492*	059	—091	*240*	143	343	704	Sum of 20
18. Ball striking	—093	003	—094	077	*328*	*242*	*279*	*240*	039	398	921	Sum of 20
19. Johnson 3	032	—086	*496*	067	—008	—089	001	014	053	672	456	Best 2 of 3
20. Johnson 4	—032	067	*643*	042	008	126	—001	—014	—053	663	731	Best 2 of 3
21. Jump and reach	*296*	217	160	129	087	—042	050	*369*	—073	385	858	Best 2 of 3
Number of variables between ± .10	14	16	15	13	15	14	15	16	18			

[1]Decimal points have been omitted.

TABLE 3
Intercorrelation of Factors—ϕ

Factor	A	B	C	D	E	F	G	H	I
A	1.000								
B	.101	1.000							
C	–.019	–.585	1.000						
D	–.366	–.205	.300	1.000					
E	–.514	.291	–.244	–.061	1.000				
F	.198	.324	–.274	.103	–.006	1.000			
G	.566	–.131	.071	–.527	–.449	–.173	1.000		
H	–.173	–.223	.205	.115	–.100	–.446	.105	1.000	
I	.273	.283	.001	.084	–.025	.527	.060	.264	1.000

Factor A has grouped the two balancing objects items where replacement was permitted if the rods were dropped before the 30-second limit had been reached. Since these two items have the highest correlation with Factor A, it appeared feasible to call this factor a *balancing objects* factor. Students who scored high on the replacement rod balance items were those who not only could keep the rod balanced, but also who could quickly replace the rod or rods before the end of the test in order that more seconds could be counted. This quick adjustment may account for the presence of Test 21—Jump and Reach—on the factor. In order to score high on this test, the subject had to quickly use the arm at the peak of the jump to record the maximum height of the jump. The appearance of Tests 16 and 17 (Basketball Distance Throw and Ball Catching respectively) is not surprising. If the sports skills are indicative of motor co-ordination, then one might expect to see these items appear on factors in an analysis of motor co-ordination.

The *balancing objects* factor in the study using college women grouped all five balance items on one factor. While the replacement balance items (2 and 3) had the highest correlation with the factor, there seemed to be no excessive premium on replacement. Moreover, the balancing objects factor in the college sample correlated positively with the sports skills factor, while this study showed a negative correlation. Perhaps there is some progression in learning to balance objects and its relation to successfully learning sports skills that needs further investigation. Conceivably, the various abilities in motor co-ordination may develop at different age levels and with the appearance of certain abilities may come the skill to perform different sports skills. Perhaps this could in part explain the negative correlation of Factor A with Factor D (total body quick change of direction—a[5]) and a positive correlation with Factor G (total body quick change of direction—b).

Factor B seems to be *speed of change of direction of the arms and hands.* This is similar to Factor D in the college sample. Factor B correlates with Factor E, which is loaded heavily with sport skill items. In the college study,

[5]The letters "a" and "b" are used to distinguish what seems to be two total body quick change of direction factors.

Factor D (speed of change of direction of arms and hands) correlated with Factor E (sports skills) although not as highly as did Factor A (balancing objects). In addition, this factor correlates positively with Factor G (total body quick change of direction—b). Test 8a (Tempo-Total Body) has the same arm exercise as Test 7 (Tempo-Arm Exercise) appearing on Factor B and probably accounts for the correlation. An explanation for the negative correlation of Factor B with Factor C will not be attempted, since Factor C is difficult to identify.

Factor C is difficult to identify clearly. The Johnson 3 and Johnson 4 items (19 and 20) have the highest correlation with this factor. In previous studies, these tests have been identified with motor educability. The present authors are hesitant to call this factor motor educability, however, because of the nature of the other items appearing on this factor. All of the items appearing on this factor require some type of quick change of direction. This factor correlates positively with Factor D (total body quick change of direction—a, identified by the Burpee and the Short Potato Race) and correlates negatively with Factor B (speed of change of direction of arms and hands). The Johnson items appeared on the total body balance factor in the college sample, and were identified with body balance because the balance items seemed narrower in concept than motor educability. In this sample, however, items other than total body balance appear. The ability that may be operating here does not seem apparent. In addition, the present authors hesitate to call this factor "motor educability" because of the nature of the concept of "motor educability." The original purpose in attempting to locate factors in motor coordination was to find some simpler operational definition of a complex concept. It is believed that motor educability is a complex concept and perhaps also could be operationally defined in simpler terms.

Factor D seems to be *total body quick change of direction—a.* Items 13 and 14 (Burpee and Short Potato Race, respectively) have the highest correlations with this factor. These items were used in the original design of the study as total body quick change of direction activities to help with identity of abilities. It was felt in the study using college women that the sports skills factor could perhaps be explained by total body quick change of direction. That study, however, did not include enough items of the total body quick change of direction type to be certain of identity. Another total body quick change of direction test (14b—Criss-Cross) was added to this follow-up study to help with more reasonable identity. However, the Criss-Cross test did not appear on this factor, and only one of the sports skills items (Basketball Throw) appeared. The absence of the Criss-Cross on this factor would indicate that it calls for a different type of change of direction than the type called for in the Burpee and the Short Potato Race. The absence of most of the sports skills on this factor may be a result of differences in ages of the two samples. Such a supposition needs further experimentation.

As pointed out previously, Factor D is correlated negatively with Factor A (balancing objects) and positively with Factor C. It is interesting to note

that Factor D correlates negatively with Factor G (total body quick change of direction—b, Tests 8a, 8b). While final proof is lacking, this suggests that a person able to change directions quickly in such items as the Burpee and the Short Potato Race will not be able to change directions quickly in activities with movement more in the vertical plane. As indicated in a footnote, the Tempo items in this study have to be interpreted as quick change of direction tests. Since the college sample contained no quick change of direction tests with movement more in the vertical plane, a similar factor could not appear. Hence, it is impossible to compare these two types of total body quick change of direction factors with the college sample. Such a comparison would help to determine whether the ability to quickly change direction develops into a more general ability or remains specific in regard to planes or patterns of movement as in this study.

Factor E has grouped the sports skills as did Factor E in the college sample. Factor E in the college sample, however, included items that Factor D and Factor E include in the elementary school sample. Perhaps there is some developmental stage when these two factors no longer manitain their identity, but are combined, as in the case of the college sample. As indicated earlier, this factor correlates with Factor B (speed of change of direction of arms and hands) and negatively with the balancing objects factor. In the college sample, this sports skills factor correlated positively with the balancing objects factor and with the quick change of direction of arms and hands. Perhaps there is a negative correlation with the balancing objects factor at the third and fourth grade level because balancing objects requires small, minute adjustments of the arms and hands not yet highly developed, and the Block tapping and Stick placing for speed are grosser movement patterns. It is interesting to note that Factor E correlates negatively with Factor G (total body quick change of direction—b) but is not correlated with Factor D (total body quick change of direction—a). Again, it should be pointed out that the *balancing objects* factor in the elementary school sample had only the rod balancing items in which *replacement* was permitted and differed from the college sample in this respect.

Factor F seems best identified as a *total body balance* factor. It is fairly reasonable to expect that successful performances on the Criss-Cross (Item 14b), the Soccer Kick for Distance (Item 15), and Ball Striking (Item 18) all are dependent to some extent upon body balance. On the other hand, an explanation of why the two-handed trick-type item 10 (Nose and Ear) would appear on a body balance factor does not seem apparent. Originally, test 9 (Crosses and Vertical Lines) and test 10 (Nose and Ear) were included because they had been used in the past as measures of motor co-ordination. These two items on a factor in the college sample helped identify a *two-handed agility* factor. However, in the present study, these two items appear on separate factors and not on the same factor. Again, one is prone to wonder if there may be some stage in development of children when a *two-handed agility* factor would appear, as in the college sample.

Factor F correlates positively with Factor B (quick change of direction of the arms and hands) and Factor I (not identified) on which the 30-second Rod Balance Without Replacement (Item 1) and Nose and Ear (Item 9) appeared. There is a negative correlation between Factor C (unidentified) and Factor G (total body quick change of direction—b).

Factor G may be tentatively identified as a *total body quick change of direction—b* factor, with the movement changes more in a vertical plane. More variables involving this type activity should be included to help with clearer identity. The correlation of this factor with the other factors has been discussed previously.

After the extraction of 7 factors, residuals still remained. This was anticipated to some extent because of the high degree of specificity in the intercorrelation matrix. Factors H and I were extracted to facilitate rotations of the other factors and in the hope that their extraction might help clarify the other factors as well as indicate clues for further study. Inspection of these factors, however, gives no apparent clue as to what is actually operating. As was suggested in the college sample, some of these factors may be perception factors, but there is no way to be positive of their identity in this study.

Conclusions

1. This study did not include enough variety of abilities to permit clear identity of some of the factors.

2. Tempo items in this study had to be interpreted as speed of movement items.

3. Four factors in this study were given names: Factor A—*balancing objects;* Factor B—*speed of change of direction of arms and hands;* Factor D —*total quick change of direction*—a; and Factor F—*total body balance.* Factor G—*total body quick change of direction—b,* with movement more in the vertical plane was tentatively identified.

4. A comparison of this study with the study using college women seems to permit the following:

A. There is much specificity indicated in the intercorrelation matrix of the elementary sample, while in the college sample many of the intercorrelations are substantial with more variables.

B. The extraction of eight factors from the college sample and nine factors from the elementary school sample reduced the respective intercorrelation matrices essentially to zero.

C. In general, groupings of variables on factors in the college sample lend themselves to relatively simple interpretation, while those same groups are split between two factors in the elementary school sample; i.e., Factors D and E in the elementary contain the same variables as Factor E in the college sample.

D. Factor A in both studies seems to be a balancing objects factor. The elementary sample, however, has balancing objects with replacement items

only and the college sample has all three balancing objects correlating substantially with the factor.

E. Factor B (elementary sample) and Factor D (college sample) are similar and were given the name, *speed of change of direction of arms and hands.*

F. Factor E in both studies has grouped the sports skills tests. This factor is correlated positively with B (speed of change of direction of arms and hands) and negatively with Factor A (balancing objects) in the elementary sample. In the college sample, Factor E correlates positively with Factor A (balancing objects) as well as Factor D (speed of change of direction of arms and hands).

G. While some of the factors in both studies are similar, this comparison would suggest that one should perhaps consider a different definition of motor co-ordination for different age levels.

Recommendations

1. This study should be repeated from the third and fourth grade levels upwards through the grades and into high school levels to determine the level at which the abilities indicated by the college sample appear.

2. This study should be repeated with similar age groups but include a wider variety of variables, such as spatial relations and speed of perception. Tempo items which are concerned more with personal "rate," such as those in the Rimoldi (3) study, probably should be included. Particularly should some items be included that would indicate how well similar age groups are able to time movements of the body.

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Studies in Human Strength[1]

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Abstract

The study points out the fact that human strength has intrigued research workers in a variety of disciplines. Selected studies dealing with strength testing and the relationship of strength to other variables are cited. Gaps in our present knowledge concerning strength are discussed.

ANYONE WHO has made even a cursory examination of the literature related to human strength realizes that the subject has fascinated many workers in all parts of the world and engaged in a variety of activities. The ramifications of the topic have cut across many subject fields, and contributions to the present knowledge of human strength are not confined to any single discipline.

The medical workers have used strength measurements as indicators of the rate of recovery from debilitating diseases (3, 23, 29, 50, 53, 56). Physical educators have used strength tests as classifying devices (69, 70, 71). Strength tests have been employed as an aid in vocational guidance (38,59,63) and as indices of growth (45, 46, 57). Research workers have attempted to relate strength to such diverse variables as body type (19, 47, 49, 54, 55, 62, 80) and the weather (31). It is only fitting that such an absorbing topic be discussed in a multitude of periodicals.

Since a complete coverage of every facet of human strength is beyond the scope of this investigation, particular attention will be given to: (1) results of strength tests and relationships between strength and other variables; and (2) some theoretical considerations of the subject. A selected coverage of strength-testing equipment has been previously published by Clarke (14) and Hunsicker and Donnelly (43).

Strength Test Results and Age

Tests of strength have been given to subjects of all ages and under a variety of conditions. Virtually all the voluntary muscle groups of the human body have been tested and a considerable mass of information is available.

The problem of relating strength with age has intrigued a number of investigators, and some large-scale testing projects have been undertaken in this area. Galton (33, 34) measured thousands of British subjects and plotted curves for height, weight, chest girth, and arm strength for ages 10 to 50; weight to 70. Some comparisons of stature statistics were made with other

[1]The major portion of this study is a Section in Wright Air Development Center Technical Report 54-548, sponsored by the Anthropology Section, Aero Medical Laboratory under Contract No. AF18 (600)-43, Project No. 7214.

nationalities. It was concluded that the strength of males increases rapidly from 12 to 19 years, and at a rate similar to that of weight; more slowly and regularly up to 30 years, after which it declines at an increasing rate to the age of 60 years. The strength of females was found to increase at a more uniform rate from 9 to 19 years, more slowly to 30, after which it falls off in a manner similar to that of males. Sargent's (74, 75) investigations of strength of athletes represent landmarks in early American strength testing.

Other similar large sample studies were done by Cathcart (7), Ufland (82), Schochrin (76), and Isikawa (44). In the main, the studies agree that muscular strength increases until approximately 30 years of age and then there is a tapering off. Cathcart found that the "black-coated" group or what we would term the "white-collar" workers were inferior to the manual workers in strength, but superior in height. His data were inadequate to determine to what extent heavy industries attract people of superior physique.

Ufland concluded that the changes of the strength of the muscles under the influence of age are different for different groups of muscles. The strength of the hand and that of the biceps, for instance, show a relatively strong ascent after the age of 20. The progressive decrease of the strength of muscles at the transition into a higher age group is most strongly pronounced in the flexor muscles of the forearm and in the muscles which raise the body. The typical curve of the changes of the strength of muscles in its dependence on age may show some deviations under the influence of occupation and constitutional types of the examinees.

Schochrin, in testing the strength of the extensor and flexor muscles of the lower legs of 1197 men and 378 women, learned that the extensors are more powerful than the flexors. The muscles of women were 28 to 30 per cent weaker than those of men. In plotting the strength curves with age, it was shown that at 40 to 45 the decrease was not so great with women as with men. Isikawa's data on grip strength follow the typical pattern when plotted with age. In a comparison of sexes, it was found that females were about 70 per cent as strong as males and the left hand about 90 per cent as strong as the right.

In a study of dynamometer strength of adult males ages 30 to 79, Donnelly (24) concluded that adults who participated in a recreational sports program were stronger than nonparticipants, but the difference was not statistically significant. Among the men who did not participate in recreational sports, the ones who were athletes in high school or college were stronger in back and total strength than the non-athletes. Weaker individuals lost a greater proportion of their strength than the stronger ones.

Erb and Rabinowitsch (29) found that subjects could squeeze more with the elbow extended than with the elbow at a right angle. The strength of women was once again determined to be about one-third less than men. People over 60 possessed about one-half the strength of younger people.

On the clinical side, it was determined that old people were slower in recovering strength after a radial fracture than young people.

Data relative to maximum grip strength and grip-strength endurance as related to age were collected from 311 male subjects ranging in age from 12 to 79 years and examined by Burke (4). It was observed that there is a from 12 to 25 years of age. After the 25th year there is a gradual decrease rapid increase in both maximum grip strength and grip-strength endurance in both items up to 79. The maximum grip strength and grip-strength endurance of the 75 to 79 years age group was approximately equal to that of the 12- to 15-year age group.

Studies made on smaller groups have been in accord with those done on large samples, but some have added information to the knowledge of the subject. Kubo (51), in a study of 355 healthy men and women between the ages of 70 and 100, concluded that grip strength and peg insertion dexterity decline with age. Memory and construction of figures do not show a sudden fall up to the age of 82. In all tests the scores at 72 or 73 years of age are highest. Restricting the study to this age group invariably introduces a problem of getting a representative sample.

Martin's (58) data showed that calculations of entire strength based on tests of only part of the muscle groups in the body are valid within a reasonable margin of error. His study confirmed Kellogg's finding that there is relatively little difference in strength between the two sides of the body. In relating strength to height, Martin demonstrated that the two varied directly. Fisher and Birrin (32) merely confirmed the findings of previous workers regarding strength and age.

Most of the studies on strength and age are of a cross-sectional design. Jones (45), in a longitudinal study which extended over a seven-year period and involved 93 boys and 90 girls, came up with some interesting generalizations. Approximately four-fifths of an adult's strength but hardly more than one-third of his height is acquired after the age of six. Few girls improve in tests which involve vigorous movement of the body as a whole, and many exhibit an actual decrease after the age of 13. Whereas, the boys' strength veered upward after age 13, that of the girls lagged behind in each function; this lag was so great that by 17.5 years the difference between the means for boys and girls was approximately three standard deviations in terms of the variability of the boys' scores, and approximately four standard deviations in terms of the variability of the girls. Those who were superior in strength at the beginning of adolescence remained superior at the end and those who were in the lower percentiles were in about the same relative status at the end of adolescence. Obviously, there were exceptions to this rule. In comparing dynamic strength with static dynamometric strength Jones concluded that the latter is more closely associated with biological growth, suggesting a greater dependence on constitutional factors expressed in physical measurements and in physiological maturing.

The variability of strength of grip is greatest in the "teens" and grip with the left hand is, as a general rule, more variable than with the right according to Arthur (1). This paper also reported a positive 0.50 correlation between grip and vital capacity with age held constant. This relationship is probably due to the fact that body size is related to both vital capacity and strength.

Strength Test Results and Skeletal Position

Numerous investigators have studied the strength that can be applied with the limbs in different angular positions. In one study (73) of the maximum torques developed in pronation and supination of the right hand, the strongest records were made with the elbow flexed to 90° and the weakest efforts with the elbow flexed to 150°. The differences in the torques exerted in different elbow positions were more pronounced in supination than in pronation. The sample was too small to permit any general conclusions from the data. In a previous study (21), the problem of fatigue between a first and second trial was shown to be inconsequential. In a majority of shoulder-elbow positions, the average torque of pronation exceeded that of supination. This was particularly marked in full extension of the elbow. Considerable variations of the maximum torques were recorded on successive occasions. Rasch (66) reported the greatest strength of elbow flexion with the forearm in mid-position, the least in the pronated position and an intermediate amount in the supinated position.

In 12 observations on three men, the average pull of the forearm flexors with the subject in the supine position and using a footboard was 102 pounds, whereas without the footboard it was 88 pounds (28). Muscle strength was greatest during the elbow flexion at 80° to 90°. In the case of elbow extension, the peak recording occurred with the elbow at 120°. Male subjects exerted a stronger pull in shoulder abduction between 10° and 40° and at a larger angle of 110°, with a slightly weaker pull in between. This was not apparent with women. In hip flexion (sitting position) strength increased almost to full extension, the peak of strength being at 150°, with only a slight decrease at 170°.

Rees and Graham (68) determined the forces that could be exerted on a footpedal with changes in backrest position. When the center of the backrest is 2 inches above the waist, approximately 11½ inches from the seat, with the thigh 15° above the horizontal and the knee angle at 160°, a maximum push can be exerted. When the thigh is horizontal, knee angle of 160°, the push is greatest when the backrest is between 12 and 14 inches above the seat. In this instance the pedal is about 4½ inches below seat level. The maximum in this case is less than when the pedal is higher.

In another investigation, Hugh-Jones (42) studied the relationship between limb position and maximum contractile force of the limb muscles. For pushing on a control, against a seat backrest, the findings suggested that the limb acts as a mechanical "toggle" between the control and the backrest. The toggle action markedly increases the exertable push and the relationship

between control and seat becomes highly critical. There apparently is a limiting angle where the action stops; for the lower limbs this was 160°, for knee extension and in the upper limbs approximately 135° for elbow extension. In the case of an isometric foot pedal, maximum pushes were obtained with the subject's thigh 15° to the horizontal and the knee joint at a limiting angle of 160°. With three groups of subjects the averages were 845 ± 35, 691 ± 66, and 689 ± 62 pounds. For an isometric hand lever, the maximum push or pull was reached with the elbow at 135° with the hand grip at about elbow height for the seated subject and the lever moving in a vertical plane which passes through the shoulder joint.

There have been relatively few studies concerned with absolute muscle force in recent years. Haxton (36) offered a figure of 3.9 to 6.15 kg per sq. cm. for the absolute muscle force of the ankle flexors. Previous estimates ranged from 0.836 to 6.24 kg per sq. cm. In a supplementary investigation (37) using tensiometers on cadaver limbs, Haxton found that in the knee and elbow joints the leverage of the action of the extensor muscles on the joints becomes greater as the joints are extended from the flexed positions. The increase is greater in the knee than in the elbow and it extends over a greater range of the movement of the joint.

The need for a standardized testing procedure is emphasized in an observation of posture and lumbar pull (2). This particular strength test has been used as an index of general muscular strength. In the administration of the test it is important that the knees be kept extended and that the handle of the dynamometer bar be adjusted to the height of the subject's middle finger tip. In this same vein, Carpenter (6) demonstrated that when the knees were flexed at 115° to 124° the highest scores were recorded in the leg lift. In the administration of the hand-grip test, there is evidence that a single effort is as reliable as either the best of three or the best of ten trials (26) and that results with untrained testers are as reliable as those with trained testers (18).

Rupp and Baranowski (72) felt that the study of human strength in general and of strength in different parts of the body in different positions is fundamental to the scientific study of the laborer. Some data are presented for strength of the hands.

Strength Test Results and Body Build

Throughout the history of man there has been a persistent interest in correlation between physical and mental ability and body type. Articles by Ciocco (8), Draper (25), Pearl (64), and Tucker and Lessa (80) summarize the abundant literature in this field. A few studies have been selected to indicate the nature of the evidence available which relates body build and strength. Lookabaugh (55) worked out the following regression equation for predicting strength from body build:

Total potential strength = 20.02 chest circumference (cms.) + 175.88 elbow width (cms.) + 85.91 knee width (cms.) — 1529.

Right grip, left grip, chest push, chest pull, thigh flexors, back lift, leg lift, and chins and dips were used in computing strength. The formula supposedly holds for men between the ages of 18 and 50, but no one has attempted to corroborate the investigation.

The development of Sheldon's (77) system of body typing gave research workers another basis for determining the relationship between strength and body type. Jones (47), in a study on 80 boys, found a correlation of 0.61 between strength and mesomorphy when height and weight were partialled out. He pointed out that individual differences in both strength and physique are chiefly dependent on common hereditary factors. Training does influence strength scores and, when the same amount of training is provided for all, it is probable that individual differences will increase. In further analysis of the strength component, Jones concluded that weight accounts for only 25 per cent of the variance in strength, whereas 75 per cent of the variance is controlled when the components of body build are included with weight and height in proportions based on a multiple regression equation. Apparently, static dynamometric strength is not dependent on gross body size, but a combination of size and body build provide a fairly adequate representation of the factors determining strength.

A zero order correlation between two variables should be carefully scrutinized before arriving at any conclusions. The data which Everett and Sills (30) presented point up the need for caution in this matter. In their study, weight correlated the highest of several variables with hand grip strength, but it is only when weight is held constant by partial correlation that the real significance of the item becomes meaningful. A correlation of 0.62 was found between hand width and grip strength. This, once again, indicated a need for using a dynamometer with an adjustable-size hand grip.

Rarick and Thompson (65) secured correlations between .58 to .63 for boys leg muscle size and ankle extensor strength. With girls this same relationship ranged between .22 and .52.

In a more recent study, Clarke (10) determined the relationship between strength and various anthropometric measurements. Although fairly good correlations, around 0.72, were obtained between arm girth measurements and certain arm strength tests the author points out that the sample was highly selective. The subjects were dominantly mesomorphic, with some tendency toward meso-ectomorphy. There is little doubt that the relationship would drop if a random sample of college students was used.

Strength Test Results and Other Variables

In some rather novel experiments on strength, Hellebrandt (39) demonstrated that exercise of one limb not only augmented the strength of the ipsilateral exercised side, but had a striking concomitant effect on the contralateral limb. In a later study Slater-Hammel (78) showed, by using 20 male college students, ten of whom received three weeks of exercise in

flexion and extension of the right arm and ten of whom were controls without special exercise, that the experimental group made a significant gain over the control group in flexion and extension of the contralateral arm. It was suggested that the exercise of one arm produces a positive and significant improvement in the muscular performance of the other arm. The implications of these findings to people in physical medicine should be obvious.

Clarke (11) reported a series of strength testing experiments using a tensiometer as well as the Kelso-Hellebrandt ergograph. In one study it was found that, even with a limited number of exhaustion bouts, the training effect, as determined by the increased distance the ergograph load can be moved, is definite and positive. In addition, improved levels of endurance were maintained during a four-week layoff.

In another research (15), procedures necessary to achieve precision in single bout elbow flexion and shoulder ergography under conditions of exhaustion testing were investigated. Objectivity coefficients between 0.75 and 0.85 were obtained for these tests. Inasmuch as the muscle conditioning effect of repeated exhaustion bouts was found to be pronounced and was not compensated for in the study, these results were considered satisfactory. The essential feature in achieving precision in single bout ergography was in determining the proper load to place on the ergograph carriage. These loads were determined objectively for each individual as a proportion of the strength of the muscles directly involved in the movement. In the case of elbow flexion, the figure was three-eighths of elbow flexion strength and in shoulder flexion five-eighths was considered the best proportion. In an attempt (13) to determine the precision with which the ergographic testing of the elbow flexion muscles could be accomplished, the results showed that a high degree of precision was possible under conditions of mild to moderate fatigue. This result held, whether the test bouts were administered ten minutes or one week apart, provided the ergograph weight load remained the same. The effect of practice on results of ergographic testing was slight when muscular fatigue did not reach the exhaustion states. In bouts short of exhaustion, precision was maintained if 30-minute rest periods were permitted between trials. Even in exhaustion sessions, a 30-minute rest period did not drop the objectivity coefficient below 0.78. However, this was below other test-retest coefficients which were generally above 0.90.

In a study of 47 different muscle groups (84), the combination of thigh flexors, leg extensors, arm flexors, and pectoralis majors was selected as having the highest correlation with a criterion of total strength.

Cureton (20) in an exhaustive study of Olympic performers and other champion athletes reported that the Danish gymnasts ranked highest as a team group in total strength. Olympic swimmers and divers were the largest group physically, but their strength per pound of body weight was the lowest of the various team of athletes studied.

Theoretical Considerations Regarding Strength

Research workers have been testing strength for more than 150 years, and it was only natural that a variety of speculations evolved in this period. A certain amount of confusion exists in the field due to the lack of a precise definition of strength. The term has been used interchangeably with muscular power, muscular endurance, muscular force, muscular efficiency, muscular fitness, contractile force, muscular tension, and others. Recently, the terms static strength and dynamic strength found their way into the literature (35, 52). Generally speaking, the former is reserved for a single maximum effort with the subject in a fixed position while the latter connotes repetitious efforts. The fact that these two are not necessarily related was demonstrated. Borrowing the term "linear impulse" from the physicists and modifying it enabled Starr (79) to describe a mathematical method of estimating the work done on a load. The estimate, expressed in dyne seconds, defines the work done on a load to start, move, stop it, and to support it without motion in similar terms. By this technique, static and mechanical or dynamic work are expressed in the same units. This method could eliminate some of the confusion in the field.

The classic experiment of Morpurgo is cited in Karpovich's text (48). It was this study that demonstrated that the number of muscle fibers does not increase in hypertrophy but that the size of fibers increases. This factor obviously imposes an upper limit on the amount of strength any particular individual can develop. The investigation of the structural changes concomitant with the strengthening process was a novel approach to the problem.

Differences in adult strength among individuals of equal weight may be due to the actual amount of tissue, bodily configuration, muscle quality, and innervation (60). It was also reported that strength shows diurnal variations, usually with a maximum in midmorning and a second maximum later in the day, but the exact time varies with different observers.

Wakim, *et al.* (83) emphasized that in every voluntary muscular act several muscle groups act as a unit. In addition to the prime movers, the antagonists, the synergists, and the fixation muscles are called into play. In the same study a comparison of the strain gauge method with the tensiometer was made. The strain gauge readings were higher, 61.1 to 57.0 pounds. Muscle power of the forearm flexors was greatest when the elbow angle was between 80° and 90°.

Students of strength testing have many times wondered whether the building of strength in the muscles moving a joint would tend to slow down the action in that joint. Three hundred weight lifters and 300 nonlifters were tested on speed of turning a rotary crank: the weight lifters proved faster than the nonlifters (89). In a different approach to the same problem, Wilkin (86) concluded that weight training over a period of one semester has no slowing effect on speed of arm movement, nor does it increase speed of movement more than a semester of swimming or golf. In another study

(22) of ten adolescent boys, five controls and five exercise subjects, progressive resistance exercise over a four-month period did not produce a slowing of contraction time. Rasch (67) in a study of speed of arm movements and the size of the arm secured correlations of a low order, .030 to .337. The problem needs additional investigation before any definitive solution can be offered.

Some workers, particularly Rogers (71), have attempted to relate strength with the state of health of the individual. There is undoubtedly some decrease in strength that accompanies certain infectious diseases but here again there is a paucity of evidence and predictions can be extremely hazardous.

Ever since the development of the ergograph by Mosso there has been a persistent interest in the measurement of muscular endurance and fatigue. Observers of physical performance knew that a single maximum effort called for a different kind of muscular condition than a sustained effort or a series of repetitious movements. The ergograph was merely the instrument for quantifying facts which were already known. The early investigations provided evidence that muscular power is impaired: (a) as a result of physical or mental work; (b) that muscular power is affected by excitement; (c) that endurance among school children is related to intelligence as indicated by class standing; (d) that endurance of boys is greater than girls; and (e) that exercise, rest, food, and increased atmospheric pressure increase endurance while local fatigue, hunger, low atmospheric pressure, high temperature accompanied by high humidity, and tobacco diminish endurance (60). It should be pointed out that in many of these studies the experimental design was not foolproof and the findings should be taken with caution. In a later research, Yochelson (88) showed that after a standard exercise a one-minute rest permitted a recovery of 40 per cent; a two-minute rest, 65 per cent; a four-minute rest, 85 per cent; and an eight-minute rest, 95 per cent. It was found that mild exercise during the recovery period was advantageous. This phenomenon is well known to coaches who insist on having an athlete continue moving about at the completion of an event to aid recovery.

Recently renewed interest in strength and endurance has resulted in a series of studies to test strength and strength loss with exercise (9, 16, 17, 61, 81). In a study of leg strength and leg strength endurance (27), the endurance time for the right leg decreased at an average of 43.4 seconds for each 100 pounds of resistance, for the left leg 34.7 seconds per 100 pounds. Correlations ranging between .36 and .45 were found between leg strength and leg strength endurance.

There have been sufficient studies to indicate that exercise will, within limits, increase strength (5.87). However, it was not until recently that any serious quantitative study of the phenomenon was undertaken. Hettinger and Müller (41) related intensity and frequency of training with development of strength. They concluded that strength increases most rapidly when training with a load that is approximately two-thirds of maximal strength. It was

further postulated that one training session per day during which the load was held for six seconds was as good as more frequent sessions or longer bouts. They attributed the improvement in strength to the development of an oxygen deficit in the muscle fiber and it is only when the training load is two-thirds of the maximum that all fibers are suffering some oxygen deficit. The rate of increase in strength was not necessarily a constant for an individual when two comparable training periods, separated by a long rest, were studied. The investigation appears to be a genuine contribution to the knowledge of the development of strength, but corroborative researches should be conducted. There is some basis for believing that all the muscle fibers involved in an action do not have identical properties (85). Hellebrandt and Houtz (40) seriously question current techniques of developing strength and endurance. They suggest that the amount of work done per unit of time is the critical variable on which extension of the limits of performance depends. At the present writing research workers are still at a loss to explain many of the phenomena involved in increasing strength.

It can be safely assumed that the instruments available for testing human strength are sufficiently valid and reliable for meeting the needs of the profession. The day-to-day strength variance in an individual is well beyond the variance in instruments. Discrepancies in reported data can often be attributed to sampling differences. A number of older studies are of little value for comparative purposes, because the sample tested was inadequately described or poorly selected. It is possible to generalize from relatively small samples but this is extremely precarious when the basic theories of sampling technique have been ignored in the drawing of the sample!

Another factor which has created differences in strength test data is the failure to insist on precisely the same testing conditions. Slight differences in the administration of a test may alter the effective forces considerably and the data will reveal differences in test administration rather than differences in strength. There is a need for more research work to shed light on the muscle groups which are actually involved in many of the strength tests.

Summary

The investigations cited in this paper have been selected from the work on human beings and largely in the area of strength testing. The following facts seem pertinent:

1. Strength increases with age for the first 25 years; remains at this level for 5 to 10 years, then decreases gradually throughout the rest of life. Physical exercise can delay the decline. The relationship between strength and age is about the same in both sexes.

2. There is only a slight difference in the strength of the two sides of the body.

3. Body type is related to strength and those possessing a high mesomorphic component have the greatest amount of strength.

4. There is a difference between static strength and dynamic strength and the relationship between the two is not high.

5. The position of the body is an important consideration when administering strength tests.

6. The exercising of one arm or limb will increase the strength of the contralateral arm or limb.

7. In muscular hypertrophy due to exercise the size of the muscle fibers and not the number increases.

8. The strengthening of the muscles about a joint does not necessarily slow down the speed of joint action.

9. Recovery from a single maximum strength effort probably takes place in less than ten minutes.

10. Four-fifths of an adult's strength but hardly more than one-third of his height is acquired after age six.

A considerable volume of work has been done on the mechanics and physiology of muscle contraction and anyone interested in these fields would profit from the studies of W. Braune and O. Fischer, Kenneth Bailey, W. Fenn, F. Henry, A. F. Huxley, A. V. Hill, L. MacPherson, P. A. Merton, O. Meyerhoff, D. M. Needham, A. Szent-Gyorgyi and D. R. Wilkie.

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Tennis Serve of Advanced Women Players[1]

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Abstract

An analytical study of the tennis serve as hit by advanced women players was conducted. Each of ten subjects hit 20 trial first services. The speed and placement of each serve was recorded, and a motion picture recording was made for selected trials. The results indicated that, for these players, there was no relationship between the speed and the accuracy of their serves. Certain differences observed in the serving movements used by the subjects appeared to be significantly related to their success, measured in terms of the speed and accuracy of their serves.

MUCH HAS BEEN written about the game of tennis for beginning players; some attention has been given to intermediate players; but comparatively little has been written for or about the advanced player. This was an analytical study of the performance of the slice serve by ten advanced women players. No attempt was made to determine by what methods or techniques the subjects had been taught to play tennis. Since most of the research in the area of motor learning has involved either relatively uncomplicated skills, fine motor co-ordinations, or novel movements, a study such as this one, of motor performance at a high level of skill involving gross and complex movements, may be of value in providing either contrast or direction.

The studies dealing with the relationship between speed and accuracy are primarily concerned with how these factors affect the learners of a motor skill. This study did not deal with these factors as they are learned but rather with the relationship of speed and accuracy as it exists among highly skilled women players. Writers of books and articles on tennis appear to have reached a general agreement that speed, accuracy, and spin are the main components of a good serve (7, 12, 13, 26, 28, 34, 36, 38, 39, 46, 47). The objective measurement of spin was beyond the scope of this study and, therefore, speed and accuracy were the only factors considered.

Purpose of the Study

The specific purposes of this study were 1. to determine the relationship between speed and accuracy of the slice serve of advanced women players; 2. to analyze and compare the serving movements of these players; 3. to compare the serves, measured in terms of speed and accuracy, with the movements used in serving; and 4. to propose a practice serving target for advanced women players. It is recognized that this study was based on a small

[1]This study was made in partial fulfillment of the requirements for the Master's degree at the University of Southern California.

number of subjects; therefore, the obtained results and conclusions should not be regarded as final. However, the subjects represented a highly skilled group and analysis of the serve and the movements used in serving by such a select group may suggest profitable avenues for further research and may provide helpful direction for the teaching of beginners.

Review of the Literature

A review of the literature relating to speed and accuracy appeared to indicate that training for accuracy at slow speeds had little advantage at higher speeds (14, 15, 16, 27, 43). In a skill involving both speed and accuracy, the subject who had practiced at a high speed had a strong motivation to continue the same type of control. However, the subject who had practiced at slow speed was forced to change the control with each change in speed. The change in movements which resulted from change in speed made it impossible to maintain the original level of accuracy. Emphasis upon accuracy did affect the type of movement used and it particularly retarded the momentum that was so necessary to a ballistic movement. Movements in which the accumulation of momentum was essential for effective performance were adversely affected by early emphasis on accuracy. In contrast to this, early emphasis on speed produced a high degree of transfer when attention was shifted to accuracy and allowed the subject to maintain the momentum that was needed in a ballistic movement. No studies were found that were directly related to the speed and accuracy of projectiles in sports activities.

Procedures

The Subjects. Ten advanced women tennis players, not students, were selected as subjects for this study.[2] The criterion for selection of the subjects was the holding of a National or a Southern California Sectional ranking for women's singles in 1954. Each subject was instructed to engage in an adequate warm-up period and was told that each of her 20 trial serves was to be an example of her best first service. The subject stood behind the baseline within three feet of the center mark on the right side of the court, and was asked to hit a slice first serve to a right-handed opponent's backhand in the right service court. The subjects knew that both time and distance would be recorded on every serve; in addition, they knew that trials number 6, 12, and 18 would be filmed.

The Experimental Court. A regulation cement-surfaced tennis court was used in this study. On the side of the net opposite the server, a large target area was designed to facilitate the recording of the serves. The arc lines measured the distance from the center spot of the serving area to the lines themselves. All measurements of distance were made with a steel tape. The letters identifying each square were duplicated on the score sheets, thus enabling the

[2]The subjects for this study were: Constance Bowan, Dennis Bradshaw, Louise Brough, Evelyn Conrad, Barbara Green, Darlene Hard, Joan Johnson, Estelle Kristenson, Geralyn Shepard, and Patricia Yeomans. Grateful appreciation is extended to them for their splendid co-operation.

recorder to record the placement of each serve more accurately. The recorder was seated above and directly in line with the area into which the majority of the serves were hit. The timer stood at the net post on the same side of the court as the recorder. An 8 mm. motion picture camera, mounted on a tripod, was placed 28 feet from the serving area on a direct continuation of the serving baseline (see Figure I).

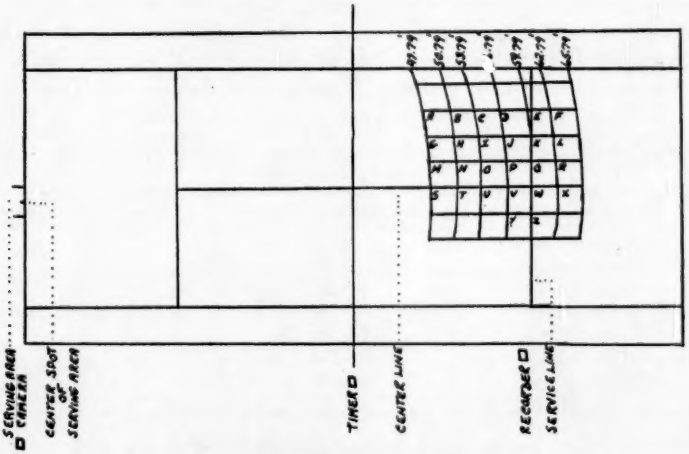

FIGURE I. The Experimental Court

The Measurements Obtained. The grip used by each subject when serving was recorded according to a method proposed by Colville (9: *p. 22*).

The placement of each of the 200 serves was recorded in the following manner. A score sheet was provided for each subject. The target area on the court was drawn to scale on sheets of graph paper. The recorder placed a small dot on the graph paper corresponding to the spot where the ball hit the court. The recorder also numbered each dot and the number of the serve was checked against a column of numbers in the margin of the score sheet.

The time lapse from the moment of impact to the moment the ball landed on the court was recorded in tenths of a second. The timer used a newly adjusted, 1/100 second stop watch. Although there is possibility of error in this method of timing, it has been shown that a reliable stop watch in the hands of a skilled operator may be used with a high degree of reliability (31: *p. 30*). The same person did all the timing for this study. A trial run was conducted prior to the actual study, thus giving all of the assistants opportunity to practice their various responsibilities.

A slow motion recording on 8 mm. film was made for three of the twenty serves hit by each subject.

Analysis of the Data

Determination of the Accuracy Score. Accuracy was scored as deviation from an empirically selected point 1½ feet from the center line and 1½ feet from the service line in the right service court (center of square P in Figure I). The choice of this spot as the center point of the target was substantiated in the literature (3, 8, 21, 32, 39, 44). Deviation from this point in tenths of a foot was determined for each of the 200 serves using the score sheets which recorded the landing point of each serve. These raw score deviations were then tallied into a frequency distribution; the mean and standard deviation were calculated; and a deviation or accuracy score value was assigned to each serve on the basis of a six standard deviation distribution (see Table 1).

TABLE 1

Accuracy Score Values Assigned to Deviations Based on Sigma Values of the Deviation Frequency Distribution[1]

Sigma Value	Deviations in Tenths of a Foot	Score Value Assigned
$-2\frac{1}{2}\sigma$ to $-1\frac{1}{2}\sigma$	0- 4	7
$-1\frac{1}{2}\sigma$ to $-\frac{1}{2}\sigma$	5- 26	6
$-\frac{1}{2}\sigma$ to $+\frac{1}{2}\sigma$	27- 48	5
$+\frac{1}{2}\sigma$ to $+1\frac{1}{2}\sigma$	49- 70	4
$+1\frac{1}{2}\sigma$ to $+2\frac{1}{2}\sigma$	71- 92	3
$+2\frac{1}{2}\sigma$ to $+3\frac{1}{2}\sigma$	93-114	2
$+3\frac{1}{2}\sigma$ to $+4\frac{1}{2}\sigma$	115-136	1

[1]The mean of this distribution was equal to 37; the standard deviation was equal to 22.

Determination of the Velocity Score. For each serve, the distance of the serve as recorded on the placement score sheets was divided by the time recorded for that serve. Thus, the horizontal velocity in ft./sec. was obtained for each serve. These raw score velocities were tallied into a frequency distribution; the mean and standard deviation were calculated; and a velocity score value was subsequently assigned to each serve on the basis of a six standard deviation distribution (see Table 2).

TABLE 2

Velocity Score Values Assigned to Velocities Based on Sigma Values of the Velocity Frequency Distribution[1]

Sigma Value	Velocities in Feet Per Second	Score Value Assigned
$+3\frac{1}{2}\sigma$ to $+2\frac{1}{2}\sigma$	132.5-147.4	8
$+2\frac{1}{2}\sigma$ to $+1\frac{1}{2}\sigma$	117.5-132.4	7
$+1\frac{1}{2}\sigma$ to $+\frac{1}{2}\sigma$	102.5-117.4	6
$+\frac{1}{2}\sigma$ to $-\frac{1}{2}\sigma$	87.5-102.4	5
$-\frac{1}{2}\sigma$ to $-1\frac{1}{2}\sigma$	72.5- 87.4	4
$-1\frac{1}{2}\sigma$ to $-2\frac{1}{2}\sigma$	57.5- 72.4	3

[1]The mean of this distribution was equal to 95 ft./sec.; the standard deviation was equal to 15 ft./sec.

The Relationship Between Speed and Accuracy. The relationship between the raw score velocities and the raw score deviations was computed using the Pearson r and Sheppard's correction. It was found that $r = .09$. This ap-

proximately zero correlation was rather surprising and indicated that there was no relationship between the speed and accuracy of the serves of these advanced players. Greater accuracy did not result when serves were hit at slower speeds; and fast serves were not any less accurate than slow serves. In other words, speed and accuracy were found to be independent factors.

Determination of the Total Score. The velocity score and the accuracy score were added together to produce a combined or total score value for each serve. The subjects were then placed in rank order according to the three criteria: velocity scores, accuracy scores and combined scores (see Table 3).

TABLE 3
Rankings for Velocity, Accuracy, and Total Score

Ranked According to Total Score			Velocity Score Ranking			Accuracy Score Ranking		
Subject	Score	Rank	Score	Rank	Per cent of total score	Score	Rank	Per cent of total score
E	235	1	118	1	50.21	117	1	49.79
F	220	2	117	2	53.18	103	3	46.82
C	219	3	108	4	49.31	111	2	50.69
B	206	4	107	5	51.94	99	6	48.06
D	206	4	112	3	54.36	94	9	45.64
G	196	6	101	6	51.53	95	7	48.47
I	182	7	97	7	53.29	85	10	46.71
A	181	8	86	8	47.51	95	7	52.49
H	179	9	78	9	44.19	101	4	55.81
J	177	10	76	10	42.94	101	4	57.06

It was found that the rankings according to velocity scores and according to combined scores were almost identical; while the ranking according to accuracy scores resulted in considerable differences. It was noted that these subjects had developed accuracy to a greater degree than velocity. This observation was first made from the nearly normal curve presented by the velocity score distribution and the curve of the deviation distribution which was skewed in the direction of greater accuracy. This development of accuracy might be due to the stress placed upon it in the game situation, but it is interesting to note that the six subjects who placed greater emphasis on velocity than accuracy were ranked within the top seven on the combined ranking. These subjects, who were able to serve at higher rates of speed while maintaining average accuracy, reached the higher levels of success. At the very highest level of skill recorded in this study, speed and accuracy received approximately equal emphasis. This subject (E) was ranked first according to all three of the criteria.

Analysis of the Movements Used in Serving. The film was analyzed in detail on a Recordak Film Reader which projected a single enlarged image of one frame at a time. Thin, transparent graph paper was placed on the view screen, and the path followed by the racket was plotted for all of the filmed serves. From these tracings, it was apparent that the fundamental movement

pattern was similar for all subjects. However, similarities among the three serves of one individual were much more pronounced than when comparisons were made between subjects. In other words, once an individual found a satisfactory movement pattern for her, she repeated that same pattern consistently.

In evaluating the differences that did appear and in trying to determine whether or not these differences were related to success in serving, tracings were made of the best filmed serve for each subject at seven arbitrarily selected critical points in the serving movement. This analysis of the serving movements used by these subjects was then compared with the rankings based on the evaluation of their serves. It was observed that the lower ranked players seemed to deviate at critical points where agreement on a common movement pattern had evidently been reached by a majority of the other subjects.

Little or no relationship was noted between success in serving and differences observed at the following points during the serving movements: the stance; the downswing; the beginning phase of the backswing; the depth of the loop; and the forward step in the follow through. This statement should not be interpreted as meaning that these elements are of no importance, but only that the differences noted among these advanced players did not appear to be related to success in serving at these points. On the contrary, it would appear that simply because of the almost complete agreement among these players on some elements, such as the stance, the downswing, and the depth of the loop, these elements should be regarded as essential.

Differences noted in the choice of grip, the degree of body rotation and backward bend, and the extension of the arm at impact all appeared to be significantly related to success in serving. The subjects who used the Continental grip were all ranked higher than 7th. The three subjects ranked last chose to serve with the Eastern forehand grip, thus indicating that the choice of grip might be an influential factor in the subsequent excellence of the serves. The higher ranked subjects deviated in the positive direction of having more body rotation and backward bend than did the lower ranked players. During the forward swing, all of the subjects except one used extended arms at impact. The one subject who used a bent arm was ranked last according to the velocity score and according to the combined score. Thus, the subjects in this study supported the authorities on tennis who advocate serving with extended arms and bodies.

For all of the subjects in this study, the movements used in tossing the ball were very similar. However, considerable variation was noted in the timing of the toss with the serving movement itself. From a study of the motion pictures obtained, it was possible to record the height of the toss, the height of the ball in the frame before impact, and the forward-backward placement of the toss. With respect to these factors, each subject maintained a high degree of consistency in tossing the ball. There did not appear to be any significant relationship between the toss of the ball and the excellence of the serve. In comparison with observations of beginners, the toss variance of

these advanced players was remarkably small. In addition, these subjects had probably attained sufficient skill in serving so that they could easily compensate with their swing for any slight variation in toss.

A Proposed Target. A circular practice target for advanced women players was proposed for the measurement of accuracy in serving. The proposed target was based directly on the placement of the 200 serves hit by the advanced women players who participated in this study. It was noted that these subjects apeared to have developed horizontal accuracy to a higher degree than vertical accuracy; they varied only 12 feet in the placement of their serves from side to side, but a variation of 18 feet was observed from the shortest serve to the longest. In consideration of this observation, it is suggested that elliptical targets might be developed for players at the higher levels of skill.

Summary

An analytical study of the tennis serve as hit by advanced women players was conducted. The specific purposes were 1. to determine the relationship between speed and accuracy of the slice serve of advanced women players; 2. to analyze and compare the serving movements of these players; 3. to compare the serves, measured in terms of speed and accuracy, with the movements used in serving; and 4. to propose a practice serving target for advanced women players.

The ten subjects were each asked to hit 20 trial serves. Each trial was to be an example of her best slice first service and was to be directed toward a right-handed opponent's backhand in the right service court. Measurements of serving grip, placement of the serve on the court, and time lapse from moment of impact to moment of contact with the court were obtained; in addition, a slow motion recording on 8 mm. film was made for three of the 20 trial serves.

Velocity and accuracy were calculated from the recordings of time and placement for each serve. Each factor was assigned a score value on the basis of frequency distributions into which the raw score values were tallied. The movement patterns exhibited in each of the three filmed serves were carefully analyzed on a Recordak Film Reader. The analysis of the serving movements used by these subjects was then compared with the rankings based on the evaluations of their serves.

A circular practice target for advanced women players was proposed for the measurement of accuracy in serving.

Conclusions

The following conclusions were drawn from this study:

1. There was no relationship between the speed and the accuracy of the slice serves hit by these advanced women tennis players. Apparently, speed and accuracy are independent factors.

2. In general, the fundamental gross movements used in serving were similar for all subjects. However, greater consistency was noted among the serves of one individual than between individuals.

a. Once an individual had developed a satisfactory movement pattern for her, she repeated the same pattern with only slight changes.

b. Some of the differences between the movements used by these players appeared at points considered critical in the total pattern.

c. These highly skilled players showed only slight variation in the toss of the ball.

3. Differences which were observed in the various parts of the serving movements used by these subjects appeared to be significantly related to success in serving as follows:

a. All of the subjects who used the Continental grip were ranked above those subjects who used the Eastern forehand grip.

b. The degree of body rotation and backward bend was positively related to success in serving; those subjects who exhibited more of these movements were ranked highest.

c. The importance of arm extension at impact was emphasized, since the only subject who used a bent arm during the forward swing was ranked last.

d. The slight variation observed in the toss of the ball appeared to have no relationship to success in serving. This was attributed to the fact that these players were probably skillful enough to compensate with their swing for any slight variation in toss.

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Effect of Instruction on Development of Throwing for Accuracy of First Grade Children [1]

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Abstract

Two experimental groups and two control groups, composed of boys and girls respectively, were studied to see to what extent instruction in the overhand throw for accuracy is practicable for first grade children. Each group received 26 twenty-minute periods of instruction in throwing or practice in games using a ball. Each group was tested five times. The results indicated no statistically significant differences between the mean gains of the experimental and control groups for either boys or girls. However, the experimental groups did have consistently higher mean gains for all test periods.

PHYSICAL EDUCATION has long been considered desirable for children in the elementary school, but very little in the way of scientific investigation has been done to place skill activities at the age where they can be learned most effectively. Teachers have differed in opinion as to when instruction in motor skills should be introduced and have debated the advisability of starting such instruction in the first grade.

A comparison of the studies made by Kane (7) and Seils (10) presents some evidence that instruction improves the motor skill of primary grade children. Kane, testing 600 children 7, 9, and 11 years of age, in the standing broad jump, obtained a mean score of 45.9 inches for children seven years of age. Seils obtained a mean score of 36.1 inches for children of the same age. Kane attributes part of the increase of 9.8 inches in jumping score to the fact that he allowed more trials than Seils and gave instruction where Seils did not.

Dusenberry (4), testing 56 children 3 to 7 years of age, in throwing distance, found training produced a significant increase in the throwing distance. On the other hand, Hicks (6), using children from the ages of 2 to the age of 6½, found that eight weeks of training in throwing a ball at a moving target yielded no greater gains in the experimental group than were produced in the control group.

Wild (13), studying behavior patterns of throwing in children 2 to 12 years of age, found there were typical age patterns for arm, body, and the hole throw. She states, "Maturational factors are believed to be operational

[1]This study was made in partial fulfillment of the Master of Arts requirements at the University of Maryland, College Park, Maryland.

as the basic type patterns of throwing develop. Learning, after six years, greatly influences the skill pattern coming out of the basic growth pattern."

Purpose of the Study

The purpose of this study was to determine if instruction in the motor skill of throwing would improve the performance of first grade children over and above the effects produced by maturation and general practice.

Preliminary Investigation

Preparatory to the actual investigation, an exploratory study was conducted with 59 first grade children to determine the types of tests to be given and the research procedure to be followed.

From the preliminary investigation, the following tests and testing procedure were devised.

Throwing—Each child was to be given 20 overhand throws at a target placed nine feet six inches from the throwing line. The target was constructed in five concentric circles in the form of a dart board. The bull's-eye was six inches in diameter with each succeeding circle six inches wider, which made the outside circle two feet six inches in diameter. Five points were given for hitting the bull's-eye and one point less for each larger circle. Each circle was colored with different colors of chalk so that when the ball struck that circle it would leave a mark on the ball.

Five chidren were brought into the gymnasium at a time. It was explained very carefully to them that a record would be kept to see which person in the class was the best thrower. The score for each throw was determined by the color on the ball, made from striking the target. If there were two color marks on the ball, the color corresponding to the higher score was used. The same balls, Voit 10-inch rubber playground balls, were used throughout the study.

Research Procedure

Two experimental and two control groups, composed of boys and girls respectively, were studied. The boys (N-21) and the girls (N-18) together received instruction in the overhand throw for accuracy for a total of 26 twenty-minute periods. The boys (N-15) and the girls (N-23) in the control groups together received 26 twenty-minute periods of play using games which involved throwing a ball, but did not receive any instruction in throwing skills.

All the children were given the throwing test five times, twice on succeeding days at the beginning of the study (tests 1A and 1B), twice on succeeding days at the end of the training period (tests 2A and 2B), and once ten days after the end of the training period (test 3). Test 1AB and test 2AB in the text refers to the average of the scores on tests 1A and 1B and 2A and 2B.

All of the subjects were first-grade pupils at the Loch Raven Elementary School, Baltimore County, Maryland. Their ages ranged from six years-four months, to seven years-two months. The study was conducted between the dates of February 3, 1954, and April 23, 1954.

Analysis of Data[2] and Findings

Reliability of the Throwing Test. The reliability of the throwing test was determined by using the Pearson product moment formula. The correlation

[2]See Appendix, p. 137, for the formula used.

of the boys (N-36) on test 1A and 1B produced an r of .84 and on test 2A and 2B an r of .79. The correlation of the girls (N-41) on tests 1A and 1B produced an r of .70 and an r of .72 on tests 2A and 2B. The differences between means was not significant for either boys or girls.

Mean Difference Between Boys and Girls. The difference between the mean of the boys (N-36) on test 1AB and the girls on test (1AB) was 5.126 points. This difference was significant at the .01 level of confidence. Therefore, for statistical purposes, four groups were to be considered—the experimental boys, experimental girls, the control boys and the control girls.

Equating of Groups. The significance of the difference between the means of the experimental and control boys and the difference btween the means of the experimental and control girls on test 1AB was computed using the t ratio. These differences were not statistically significant for either boys or girls.

Significance of the Difference Between Improvement of Groups. The significance of the difference between the mean gains or losses of the experimental and control boys and the experimental and control girls was calculated for each test period using the t ratio scale.

Mean Gains of Boys. The mean gains of the experimental and control groups of boys for each test period are shown in Table 1, on page 6. The boys in the experimental group had a mean gain of 5.928 points from the initial test (test 1AB) to the end of the training period (test 2AB). This gain was significant at the .01 level of confidence. The mean gain of .38 points from test 2AB to the test given after a ten-day lay-off (test 3) was not statistically significant. The mean gain of 6.308 points from test 1AB to test 3 was significant at the .01 level of confidence.

TABLE 1

Significance of Mean Gains of Boys' Experimental and Control Groups

Item		test 1AB-2AB	test 2AB-3	test 1AB-3
experimental N = 21	mean gain	5.928	.380	6.308
	standard deviation	4.88	4.98	4.518
	t - ratio	5.644*	.352	6.394*
control N = 15	mean gain	5.666	—.476	5.190
	standard deviation	4.072	5.783	10.486
	t - ratio	5.43*	—.321	1.96
Difference between mean gains	difference	.262	.856	1.118
	t - ratio	.177	.469	.393

*Indicates significance at .01 level of confidence. None of the remaining ratios met the .05 level of confidence.

The boys in the control group had a mean gain of 5.666 points from test 1AB to test 2AB, which exceeded the .01 level of confidence. The loss of .47 points from test 2AB to test 3 was not significant, and the over-all gain of 5.190 points from test 1AB to test 3 was not significant.

The difference between the mean gains of the boys in the experimental group and the boys in the control was not significant for any period.

Mean Gains of Girls. The significance of the mean gains of the girls' experimental group and the girls' control group is shown in Table 2. The girls in the experimental group had a mean gain of 5.66 points from test 1AB to test 2AB and this gain was significant at the .01 level of confidence. The gain of 2.69 points from test 2AB to test 3 was significant at the .05 level of confidence. The over-all gain from test 1AB to test 3 (8.35 points) exceeded the .01 level of confidence.

TABLE 2

Significance of Mean Gains of Girls' Experimental and Control Groups

Item		test 1AB-2AB	test 2AB-3	test 1AB-3
experimental N = 18	mean gain	5.66	2.69	8.35
	standard deviation	5.154	4.763	7.003
	t - ratio	4.677*	2.401**	5.04*
control N = 23	mean gain	2.89	2.93	3.26
	standard deviation	7.16	4.620	6.427
	t - ratio	1.455	2.280**	3.26*
Difference between mean gains	difference	2.77	.240	2.53
	t - ratio	1.150	.161	1.03

*Indicates significance at .01 level of confidence.
**Indicates significance at .05 level of confidence. None of the remaining ratios met the .05 level of confidence.

The mean gain of 2.89 points for the girls in the control group for the period from test 1A to test 2AB was not significant. The gain of 2.93 points from test 2AB to test 3 exceeded the .05 level of confidence. The gain of 5.82 points for the entire period from test 1AB to test 3 was significant at the .01 level of confidence.

The differences between the mean gains of the experimental and control groups were not statistically significant for any of the test periods.

Summary

The findings of this study indicate that instruction of first grade children in a motor skill such as throwing for accuracy does not improve the skill of the child over and above what is to be expected to occur by practice without instruction. However, it should be noted that the improvement in throwing for both the boys' and girls' groups was greater for these groups which received instruction; this was especially true for the girls. This suggests that, if the study had been carried out over a longer period of time, perhaps the results would have been statistically significant in favor of the groups receiving instruction.

Recommendations

The results of the study, although not statistically conclusive, indicate that instruction may have a beneficial effect upon throwing for accuracy; therefore, the following is recommended:

1. That a similar study be conducted over a longer period of time and with perhaps different or more tests.

2. That further investigations be conducted to determine at what age instruction in throwing for accuracy will produce significant gains in throwing score over and above the effects produced by general practice and maturation.

3. That a long-range study be made to see if instruction in throwing for accuracy at the age level discovered in recommendation two above will produce significant differences in throwing ability in later grades.

4. That a study be made at the first grade level to determine how much general play practice without instruction will improve throwing score over and above the improvement that is due only to maturation.

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APPENDIX

Formula Used in Statistical Analysis

Reliability of Throwing Tests

The formula used for the correlation of r:

$$r = \frac{x'y' - \frac{(Zx'y')(Zfy)}{N}}{\sqrt{Zfx^2 - \frac{(Zfx)^2}{N}} \quad X \sqrt{Zfy^2 - \frac{(Zfy)^2}{N}}}$$

The formula used to determine the significance of mean difference:

$$t = \frac{M_1 - M_2}{\sqrt{M_1^2 + M_2^2 - 2rM_1M_2}}$$

Mean Difference Between Boys and Girls and Equation of Groups

$$t = \frac{M_1 - M_2}{\sqrt{M_1^2 - M_2^2}}$$

Mean Gains of Boys and Girls

The statistical significance of the mean changes of the groups was computed from the raw scores in the following manner:

1. Computation of mean difference, Md.
2. Computation of the standard deviation of the population.

$$\sigma d = \sqrt{\frac{Zd^2}{N - 1}}$$

3. Standard error of the mean.

$$\sigma Md = \frac{\sigma d}{\sqrt{N}}$$

4. Computation of t ratio.

$$t = \frac{Md}{\sigma Md}$$

5. Computation of t ratio for difference between experiment and control group mean gains.

$$t = \frac{M_1 - M_2}{(\sigma Md_1)^2 - (\sigma Md_2)^2}$$

(Submitted 9/6/56)

An Experimental Technique for Reporting Recreation Services Rendered on Public Playgrounds

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Abstract

This study was designed to describe more clearly the services offered public playgrounds and to find a method whereby these services could be portrayed on a statistical reporting form. In making this description, new concepts of the distribution of patrons and leadership staff on a playground were applied. Two playgrounds were compared to see if the concepts did discriminate in a useful way. Results indicated that the addition of data relative to staff services is extremely useful and furnishes a better gauge of services rendered than existing attendance-taking methods.

NUMEROUS WRITERS in the recreation field have cited the importance of adequate statistical reporting for developing and administering sound playground programs. Stevens (13) states statistical recording is essential for such aspects of recreation work as planning, finance, agency interpretation, administration, and standard setting. Similar views have been expressed by Butler (1, 2), Ridley and Simon (11), Hjelte (6), and others (7).

That currently used reporting forms are not adequate to fulfill the above purposes, has been noted by a number of the above authorities. For the most part, these objections have been concerned with the lack of systematized information available from reporting systems. Hjelte's criticism goes further and points out that the currently prevalent use of attendance and registration counts describes only patron use of playgrounds, and no matter how detailed, has at best limited use for such purposes as program evaluation, standard setting, etc.

To meet these latter objectives, the authors contend it is necessary to collect statistics with respect to another dimension—the activities of staff. It seems mandatory that if playground reporting is to become a more valuable and accurate tool for administrators, it must furnish information regarding not only playground use, but also playground staff services.

In line with the above discussion, this study was designed to:[1]

[1]This study entitled, *Public Recreation Service Units*, was conducted under the auspices of the Youth Services Division, Welfare Planning Council, Los Angeles Region. It has been published by the Research Department of the Council. The authors gratefully acknowledge the invaluable assistance given them by John Pixley and Elisabeth Frank of the Council and George Hjelte and William Frederickson, Jr., of the Los Angeles City Department of Recreation and Parks.

(a) devise systematic patron participation and staff service units which would be potentially meaningful for playground reporting, and
(b) test the validity and usefulness of these units by means of an empirical inquiry intended to determine the relationship between playground staff services and patron use of facilities.

Procedure

The study consisted of two principal phases:

Phase I. Owing to the lack of adequate formulization of playground staff operations and patron activities, it was necessary for salient aspects of each to be identified. To accomplish this, a pilot project was conducted at three public playgrounds. These playgrounds were located in areas with different socio-economic characteristics so as to control possible bias resulting from certain services being uniquely determined by social characteristics of communities. The project consisted of a week-long time and motion study in which activities of playground staff and patrons were narratively recorded. These records were then analyzed in order to develop terms or activity units which might serve as a base for describing the activities actually observed in the course of the pilot project.

Phase II. The second step in the study consisted of determining whether the activity units developed in the pilot project were meaningful. Two playgrounds which were considered representative of good program content and which were comparable to one another in size were used.[2] As in the pilot project, these playgrounds were so chosen that the communities served by them were quite different. Playground A served almost exclusively a Caucasian, middle-population. Playground B served an area composed of lower-class families, over 60 per cent of whom were of either Mexican-American or Negro extraction.

After an initial training period, observers were assigned to the playgrounds for a period of one week. Each playground staff member had an observer assigned to him. In addition, "floater" observers were provided to record activities of patrons.

The method of observation utilized was similar to that of the pilot project. However, rather than narratively recording staff and patron activities, observers recorded on tally sheets containing the activity units developed in the first phase of the study. Recording was in terms of the actual minutes expended by staff and patrons in the activities described in the tally sheets. A normal program week was chosen for the observation period, during which the effects of inclement weather were minimal.

Findings: Phase I

From an analysis of the narrative recordings taken during the pilot project, a number of terms were developed which, it was felt, could provide a

[2]Neither of these two facilities was included in the pilot project.

meaningful description of playground activities. These terms are briefly defined below:[3]

STAFF ACTIVITIES

Staff duties fall within three general service areas, only one of which directly relates to patrons. These service areas include:

1. Services to the community;
2. Indirect services to patrons; and
3. Direct services to patrons.

In rendering *services to the community*, staff duties are focused toward the neighborhood rather than agency users. They have as their purpose the creation of more understanding and acceptance of the agency by citizenry. These duties include the following specific tasks: 1. participating in agency interpretation conferences; 2. attending community meetings; 3. holding conferences on use of playground facilities; 4. planning; and 5. student training.

In rendering *indirect services to patrons*, staff engages in a variety of activities which deal with the maintenance and administration of facilities and equipment. Their primary purpose is to render better service to the patron. Duties carried out in giving this type of service include: 1. administrative duties; 2. equipment control; 3. training and supervision of volunteers; 4. maintenance of facilities and equipment; and 5. miscellaneous duties.

Direct services to patrons encompass a large number of specific tasks. Functionally, however, these tasks can be combined into four broad activities:

1. Overviewing and supervising use of facilities;
2. Contacts with free-play (non-scheduled) groups or individuals;
3. Contacts with scheduled groups; and
4. Scheduled contacts with individuals.

PARTICIPATION ACTIVITIES

Patron use of playground facilities was characterized during the study in much the same way as suggested by the National Recreation Association and the American Recreation Society in 1954 (5). The various specific types of activities in which patrons engage (club meetings, playing football or basketball, etc.) were grouped in three general categories:[4]

1. *Scheduled activities.* These are activities which are scheduled by the agency to take place at specific times. The activities may be scheduled on a recurring basis (as with club meetings and league sports events), or they may be short-term functions (such as tournaments, dramatic productions, etc.).

2. *Free-play activities.* This grouping of activities pertains to those engaged in by individuals who while not participating in scheduled programs, nevertheless are using playground facilities and/or equipment.

[3]Because of space limitations, the definitions of terms as presented here are necessarily brief. More comprehensive and detailed definitions are to be found in the original publication.

[4]Although reporting of specific activities in scheduled program is essential in statistical reporting, the aims of the study did not demand such detailed definitions, and they are therefore excluded here.

3. *Spectator activities.* These activities are those engaged in by patrons who make no use of equipment or facilities (with the possible exception of benches and grandstands), do not engage in any programs or games, but rather, observe activities of others.

THE ZONE CONCEPT

In the course of the pilot project, it appeared that the relationship between staff leadership operations and patron activities should not only be seen as a function of the types of activity engaged in, but also as a function of the playground area in which the activities occur. Four such areas or zones were defined. Their descriptions are given below:

1. Zone I includes the office building and the indoor facilities within the building (such as classrooms and gymnasiums) and immediately adjacent to this, the office porch area with space for such games as ping-pong, caroms, shuffleboard, etc. In this zone, staff carries out most of its administrative functions, meets with scheduled clubs and classes, issues and receives equipment, and holds conferences.

2. Zone II surrounds Zone I and includes facilities and equipment for such activities and games of low organization as use of swings and gymnastic apparatus, tetherball, volleyball, basketball, hop-scotch, and the like. Staff may provide some supervision and/or organization of free-play activity. Instruction is of a minimum nature with staff functions frequently being expressed in arbitrating between participants and in enforcing agency rules and regulations.

3. Zone III includes the field spaces with facilities for team games and sports and provision for spectator facilities. Special equipment and field maintenance is necessary for the use of this area. Staff investment tends to involve more direct supervision and skill instruction.

4. Zone IV is the fringe area and embraces those facilities and areas on a playground that are usually found on the outer perimeter, such as benches, picnic tables, tennis courts, etc. Staff functions are of a nominal supervision type.

It should be noted here that all four areas or zones do not necessarily exist on every playground. However, this does not affect the concept of activity zones, for in such cases staff investment is merely concentrated in those zones which are present.

Findings: Phase II

As previously indicated, the test of the usefulness of the activity units was in the information they furnished for an empirical inquiry. If by their use data could be gathered which revealed important facts about playground operations, their value would be demonstrated. The following examples are illustrative of the actual information obtained by the study.

A. STAFF SERVICE FUNCTIONS

In terms of their *broad* service functions, the staffs of Playgrounds A and B showed considerable similarity. Staff at Playground A spent 49.2 per cent

of its time giving service to patrons, 49.9 per cent in rendering indirect service to patrons, and 1.9 per cent in service to the community. Corresponding percentages for Playground B were 53.3 per cent, 42.7 per cent and 4.0 per cent. Thus, while direct services to patrons consumed the largest bulk of time for both staffs, indirect services were almost equally stressed, and service to the community received little emphasis.

In Table 1 a detailed breakdown of the distribution of staff time within the broad service areas mentioned above is given. Again, considerable similarity is seen between the playgrounds in their pattern of rendering services. In giving direct services to patrons, both staffs concentrated primarily on work with scheduled groups, with considerable focus also spent on free-play participants. Indirect services to patrons were dominated by administrative duties, with the remaining time spent in a number of diverse activities. While some differences appeared in the distribution of services rendered to the community, the paucity of time spent by either staff in this general service area makes it difficult to determine their significance.

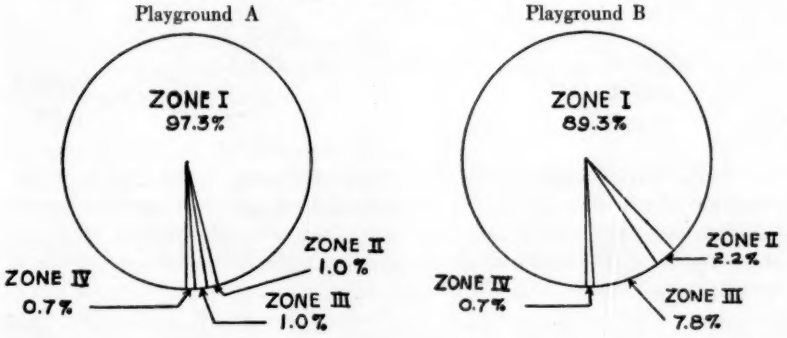
Staff Time by Zones. A striking feature of the distribution of staff time is that, at both playgrounds, the vast majority of this time was spent in Zone

TABLE 1
Distribution of Staff Time by Playground

Service	Playground A %	Playground B %
Direct Service to Patrons		
Overview and Supervision of Facilities	9.9	11.3
Contact with Free-Play Groups or Individuals	21.2	23.9
Contact with Scheduled Groups	54.8	59.2
Scheduled Contacts with Individuals	14.1	5.6
Total	100.0	100.0
Indirect Service to Patrons		
Administrative Duties	47.7	48.5
Equipment Control	9.7	7.7
Training and Supervising Volunteers	.3	.3
Maintenance of Equipment and Facilities	9.3	6.8
Miscellaneous	33.0	36.7
Total	100.0	100.0
Service to the Community		
Agency Interpretation	24.5	43.4
Attendance at Local Meetings	61.2	30.6
Conference on Use of Facilities	14.3	19.4
Planning	0.0	3.6
Student Field Work	0.0	0.0
Services Related to Profession	0.0	3.0
Total	100.0	100.0

I (see Chart I). At Playground A, over 97 per cent of staff services were rendered in this zone, while at Playground B the figure was almost 90 per cent. Differences did exist between the playgrounds in the distribution of staff time in the remaining zones, with Playground B staff concentrating most of its remaining time in Zone III, and staff at Playground A distributing its remaining time almost equally among the three zones.

CHART I.
Distribution of Staff Time by Zones



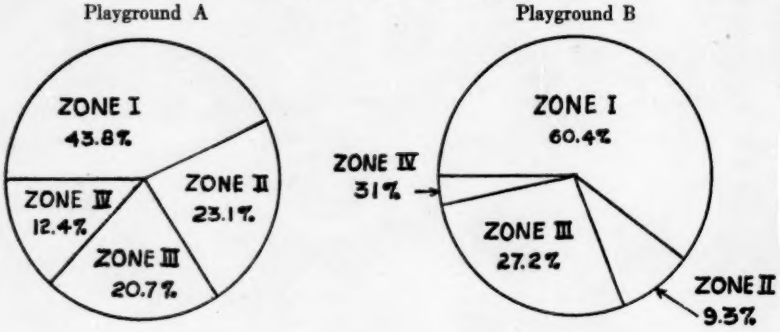
B. PATRON ACTIVITIES

Because of the limited number of field staff, it was not possible to record either the actual number of participants at the playgrounds observed, nor the time each patron spent on the playground. Therefore, an alternative method was used in which observations to obtain the number of participants in each zone, and the activities in which they engaged, were made at half-hour intervals. Such a procedure is subject to limitations. However, because of the frequency of observations, the counts obtained were felt to be quite accurate in terms of estimating the actual volume of participation at the two playgrounds.

Patron Participation by Zones. The manner in which participants made use of the facilities at Playgrounds A and B is shown in Chart II. For both playgrounds, Zone I received the greatest use, while Zone IV received the smallest. In terms of the amount of participation in each zone, however, the two playgrounds were at variance with one another. The distribution of participation at Playground A was fairly uniform, ranging from 44 per cent in Zone I to 12.4 per cent in Zone IV. At Playground B, however, over 60 per cent of that participation occurred in Zone I, while only 3.1 per cent took place in Zone IV.

Inter-Zone Distributions of Patron Activities. In order to more adequately specify the differences shown in Chart II, the inter-zone distributions of patron activities (scheduled, free play, etc.) were determined. These findings (Table 2) point out that 1. at each playground the inter-zone distributions

CHART II
Patron Participation by Zones



of activities varied considerably from one another, and 2. the inter-zone distributions of two activities at one playground (free play and spectator) were different from those of the same activities at the other playground. The participation distribution of scheduled groups at the two facilities, however, appeared fairly similar.

TABLE 2
Patron Activities by Zones

Zone	Patron Activities							
	Scheduled Playground		Free Play Playground		Spectator Playground		Total Playground	
	A	B	A	B	A	B	A	B
	%	%	%	%	%	%	%	%
I	76.8	69.3	30.3	59.6	26.5	39.0	43.8	60.4
II	4.2	0.0	31.0	20.9	30.0	1.1	23.1	9.3
III	15.4	29.6	21.6	13.7	39.3	59.3	20.7	27.2
IV	3.6	1.1	17.1	5.8	4.2	0.6	12.4	3.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Discussion

The above findings are representative of the information which can be obtained via statistical reporting when such reporting provides information with respect to staff services as well as patron participation, and also is made more discriminating by use of additional concepts (i.e., the zone concept). It is felt these findings might well be of value to recreation administrators. Such facts as these would seem vital in determining how adequately different types of clientele are being served. For example, with respect to the finding that playground staff members spend little time in Zones II, III, and IV (about 10 per cent), while between 40 to 60 per cent of the patrons were in

these zones, one might raise the following questions:

1. Is this zonal distribution of staff time considered desirable?
2. If not, what would be considered desirable?
3. Should the time devoted to each zone vary with the way patrons use the facilities? If so, how?

It is apparent that answers to the above questions suggest standards which staff members should meet in carrying out their jobs. The importance of such standards should not be underestimated, for with their establishment it becomes more possible to explicate the job of the playground director. Without question, these standards will lack precision for some time. Nevertheless, they may furnish a better gauge of services than is presently available in the recreation field.

Recommendations for Further Study

Although a number of possible studies are suggested by the findings of this project, two very important areas needing further research should be mentioned. First, the finding regarding the different uses made of Playgrounds A and B by participants might in large measure be accounted for if it were known what different types of participants desire to do at playground facilities. Determining the recreation patterns of persons in terms of their age groupings, income levels, cultural affiliations, etc., would provide a partial answer to this question. But further research asking people directly what they desire from playground programs should be attempted in the future in order that service needs of different types of individuals can be ascertained.

Another very important question in need of investigation concerns the job performed by playground staff. The units relating to staff operations, as used in this study are limited in that they do not describe services, but rather are only concerned with staff activities. To depict services, it is necessary, in addition to describing staff activities, to state the purposes of such activities. As yet, however, operational statements of purpose have not been formulated in the recreation field. Studies focusing on obtaining this information, therefore, are sorely needed in order that further clarification of the nature of recreation services may be achieved.

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Effect of Warm-up Activities on Speed, Strength, and Accuracy

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Abstract

Three groups of women physical education majors, totaling 31 students, participated in a series of tests to determine the effects of light warm-up activities on speed, strength, and accuracy. The tests used in the study were (1) speed—a ride of one-tenth of a mile on a bicycle ergometer, (2) strength—the maximum distance a subject could throw a softball and (3) accuracy—the number of successful basketball free throws a subject could score in ten tries. The data were analyzed in terms of the above tests, each of which were performed when preceded by no warming up, by a general warm-up, and by a warm-up related to the test activity. A total of 360 usable tests were recorded. The results indicated that there were no significant differences in the scores made in relation to the three types of warm-up procedures. Also, no injuries or soreness were reported during the testing period.

IT WAS THE purpose of this study to determine the effect of light warm-up exercises of the type often done in girls' physical education classes on the performance of certain activities involving speed, strength, and accuracy.

Discussion of the Problem

Most of the literature on the subject of warming-up tends to indicate that such activities are of value. The almost universal practice by teachers of physical education and coaches to insist on warm-ups before games, track meets, and other performances probably stems from studies relating to the treppe phenomenon, (14; 34) heat production in muscle, (14; 29) viscosity of muscle, (10; 1) and from tradition. Available literature in the form of articles on athletics, studies reported in journals of physiology, and textbooks in both general physiology and physiology of exercise apparently favors the practice or warming-up. However, certain recent studies have questioned the necessity for, and the actual effect of, warm-up activities, (15; 16).

A review of statements relating to the treppe phenomenon indicated that experiments in this area have been done almost exclusively on isolated muscles of animals, (13; 30). Reference to the treppe effect in humans is not explicit and is made in such terms as "apparently" (14; 34) and "gives a clue" (13; 30).

Studies on the relation of temperature to the capacity for work indicate that an increase in temperature increases the work performance (1). However, differences of opinion exist regarding the best methods for increasing muscle temperature.

While much of the published material agrees with the practice of warming up, there seems to be little clear-cut scientific evidence that conclusively sup-

ports such practice. Since the doubts provoked by Schneider and Karpovich (15; 14), Hale (8), and Hipple (9) were not dispelled by a review of available literature, the authors were motivated to undertake the present study.

Procedure

Thirty-one women physical education majors volunteered to participate in a series of tests. They were given no information regarding the purpose of the tests. The volunteers were randomly assigned to three groups: Group I rode a bicycle at top speed for one-tenth of a mile; Group II had three tries at throwing a softball for distance; and Group III tossed ten basketball free throws.

The general procedure for all three groups was the same. Preceding all testing, each subject rested quietly for at least five minutes before performing any of the tests. On a given day of the first week, each group performed their activity with no warm-up of any kind. On the same day of the second week, with no practice in between, the activity was performed, preceded by a general warm-up in which all groups performed 12 jumping jack exercises prior to the activity. On the same day of the third week, the activity was performed following a related warm-up in which the subjects warmed up with activity involving the same type of muscle action as that used in the actual test activity, namely, throwing a softball.

The members of Group I (8 subjects) were tested on speed as measured by the time in which they could ride one-tenth of a mile on a stationary bicycle ergometer. The week before testing was to begin they were given a trial run so that they might become familiar with bicycle and starting signal.

On the first test day, the subject rode one-tenth of a mile at top speed and her time was recorded to the nearest tenth of a second. For the second test each subject was asked to do 12 jumping jack exercises. Immediately following the warm-up, she rode the bicycle as fast as possible. For the third test the subject rode the bicycle the distance of eight revolutions at a moderate speed prior to the timed ride of one-tenth of a mile.

The members of group II (9 subjects) were tested for strength as measured by the distance they could throw a softball. The procedure described for group I was followed except that at each testing period the subject was given three trials and the related warm-ups involved five overhand softball throws to a partner at a distance of 30 feet.

The members of group III (13 subjects) were tested for accuracy as measured by the number of baskets they could make in ten free throws. Again, the same general procedure was followed except that the related warm-ups consisted of three free throws taken prior to the test of ten free throws.

Each subject was tested a total of 12 times: the tests on the 1st, 4th, 7th and 10th weeks were preceded by no warm-up exercises; the tests on the 2nd, 5th, 8th and 11th weeks were preceded by general warm-up exercises; and the tests on the 3rd, 6th, 9th and 12th weeks were preceded by related warm-ups. A total of 360 usable tests were recorded. Prior to each test,

each subject was asked to describe any muscle soreness or injury which may have resulted from the previous test. A record was kept of the answers.

Analysis of the Data

Analyses of variance techniques were applied to the work performance of three groups to determine the effect of no warm-up, a general warm-up and a related warm-up on the test scores for speed, strength, and accuracy.

GROUP I—BICYCLING FOR SPEED

There was no significant difference among the three warm-up methods. The speed with which a subject could ride one-tenth of a mile was not appreciably different on days when the subject did not warm up from the days when either a general or related warm-up was done prior to the ride. Although the average girl improved her time by three-tenths of a second when related warm-ups preceded the trials, the difference was not statistically significant (see Table 1).

TABLE 1

Analysis of Variance for Group I (Bicycling for Speed) Tested Under Three Warm-up Methods

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Between Warm-Up Methods A. B C	1.64	2	.820	.08
Between Subjects in Same Group	204.61	21	9.743	
Total Between Subjects	206.25	23		
Between 4 Series of Tests	14.63	3	4.876	71.70*
Interaction: Trials × Conditions	.41	6	.068	.49
Interaction: Pooled Subjects × Trials	8.70	63	.138	
Total Within Subjects	23.74	71		
Total	229.99	95		

*Significant at .01 level of confidence.

The F for trials was 71.70, which is highly significant at the .01 per cent level and indicated that the mean scores on different days do vary (see Table 1). An analysis of the data shows that the scores improved on succeeding tests regardless of the method of warm-up involved. However, the scores following related warm-up were better and showed more improvement than those following no warm-up or general warm-up (see Table 2).

GROUP II—SOFTBALL DISTANCE THROW

This test consisted of three throws for distance. There was no significant difference among the three warm-up methods (see Table 3), nor was the difference significant among the first, second and third trials of a given test (see Table 4). Although not statistically significant, there was a tendency for the second throw to be better than either the first or third when the test was preceded by no warm-up or unrelated warm-up. In the tests preceded by related warm-up, the first trial was the best, probably owing to the fact that the warm-up was similar to the muscle action used in the test itself. There was no significant difference among the scores on different days when the

TABLE 2

Mean Scores for Three Different Activity Groups Using Three Types of Warming Up

Type Activity	Series 1	Series 2	Series 3	Series 4	Combined Mean	Range
Group I. Bicycling[1]						
No Warm-Up	13.34	13.19	12.60	12.59	12.9	11.3-
Unrelated Warm-Up	13.51	13.15	12.47	12.49	12.9	14.6
Related Warm-Up	13.22	11.77	12.37	12.19	12.6	sec.
Group II. Softball Throw[2]						
No Warm-Up	37.50	36.50	36.48	37.35	36.96	20.0-
Unrelated Warm-Up	36.02	37.00	37.31	35.17	36.38	55.3
Related Warm-Up	38.51	39.09	37.83	38.23	38.42	yds.
Group III. Basketball Free Throws[3]						
No Warm-Up	3.15	2.54	3.31	3.31	3.08	
Unrelated Warm-Up	2.23	2.69	2.77	3.31	2.75	0-7
Related Warm-Up	2.77	3.07	3.38	3.31	3.13	

[1]Scores in seconds.
[2]Scores in yards, average of three trials taken on one day.
[3]Number of baskets made, average of 10 trials taken on one day.

TABLE 3

Analysis of Variance for Group II (Softball Throw) Tested Under Three Warm-Up Methods. Average of Three Trials on One Day.

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Between Warm-Up Methods A. B. C.	79.54	2	39.77	.17
Between Subjects in Same Group	7499.46	32	234.35	
Total Between Subjects	7579.00	34		
Between Series 1, 2, 3, 4	5.26	3	1.75	.29
Interaction: Series × Methods	35.54	6	5.92	.48
Interaction: Pooled Subjects × Series	788.50	64	12.32	
Total Within Subjects	829.30	73	11.36	
Total	8408.30	107		

trials on one day were averaged. However, scores were better following related warm-up than they were when no warm-up or unrelated warm-up preceded the tests (see Table 2).

GROUP III—BASKETBALL FREE THROWS FOR ACCURACY

There was no significant difference among the methods of warm-up (see Table 5). While not statistically significant, there was a tendency for higher scores to result on tests which followed related warm-ups. There was no significant difference among scores on different days, all scores tending to increase from day to day (see Table 2).

MUSCLE SORENESS

In all tests, no injuries were reported. Eight reports of muscle soreness were received. Of these, four were subjects in the softball group and four

TABLE 4
Analysis of Variance for Group II (Softball Throw for Distance) for Trials 1, 2, and 3

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Between Warm-Up Methods A, B, C	66.78	2	33.39	.14
Between Subjects in Same Group	5610.77	24	233.78	
Total Between Subjects	5677.55	26		
Between Trials 1, 2, and 3	2.27	2	1.13	1.88
Interation: Trials × Methods	2.41	4	.60	.04
Interaction: Trials × Methods	714.55	48	16.89	
Total Within Subjects	719.23	54	13.32	
Total	6396.78	80		

TABLE 5
Analysis of Variance for Group III (Basketball Free Throws) Tested Under Three Warm-Up Methods

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Between Warm-Up Methods A, B, C	4.47	2	2.235	.70
Between Subjects in Same Group	109.01	36	3.028	
Total Between Subjects	113.48	38		
Between Four Series of Tests	9.76	3	3.253	1.86
Interaction: Trials × Conditions	10.49	6	1.748	.73
Interaction: Pooled Subjects × Trials	256.25	108	2.372	
Total Within Subjects	276.50	117		
Total	389.98	155		

were in the bicycle group. The four who reported arm soreness attributed it to participation in modern dance, hockey, and tennis serve practice. All four instances of leg soreness from bicycling were reported by the same subject, and she described the soreness as slight.

Summary and Conclusions

In an effort to determine the effect of light warm-ups on performance, 31 subjects were given a series of tests involving strength, as measured by the distance a softball could be thrown; speed, as measured by the length of time it took to ride a stationary bicycle one-tenth of a mile; and accuracy, as measured by the number of successful free throws made out of ten tries. Each test was given in the following series: (a) preceded by no warm-up; (b) preceded by a general warm-up; and (c) preceded by a related warm-up. Each subject repeated each series of tests four times. It was found that:

1. Neither the presence nor absence of light warm-ups of short duration appeared to affect significantly the performance of players of average skill.
2. Although not statistically significant, scores generally improved as a result of practice.
3. While there was no significant difference among scores in three different activities using three methods of warming up, a slight tendency toward

better scores was noted in tests which were preceded by related warm-ups.

4. No injuries resulted from an absence of warm-up activity, nor was any muscle soreness directly attributed to failure to warm up prior to performance.

Recommendations for Further Study

1. A study of the present type, but involving an intensive warm-up period, rather than a light warm-up, would be of value.

2. Studies regarding the relative effects of warm-ups of various types, duration, and intensity on skilled and non-skilled performers might produce results of value to teachers and coaches.

3. The inter-relationship of the learning process and the use of warm-ups could be studied to advantage.

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Measurement of Kinesthetic Perception of Muscular Force with Muscle Potential Changes

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Abstract

A technique for using muscle potential changes as a measure of the kinesthetic perception of muscular force is described. Application of the technique to selected groups of male and female physical education majors and liberal arts majors revealed that: (1) the constant error for all groups was positive; (2) the difference in constant error between sexes was not significant, but the constant error for physical education majors was significantly smaller than that for liberal arts majors; and (3) the differences in variable errors between sexes and major groups was not significant.

IT HAS BEEN noted elsewhere (8, *p. 471*) that the available kinesthetic tests on the perception of muscular force also involve tactical stimulation. In these tests, the subject (S) is usually required to exert muscular force against weighted objects (11), scales (9), dynamometers (11), or a loaded lever (6). Since these procedures involve touching and pushing against objects, it is impossible to determine whether S responds to kinesthetic stimulation, tactical stimulation, or a combination of kinesthetic and tactical stimuli.

Any attempt to measure kinesthetic perception in the absence of tactical stimulation would require a situation in which the body part under investigation had no forceful contact with objects in the physical world. And in this situation, it would be necessary for both S and the investigator to obtain quantitative information on the former's muscular exertions. Although such demands are difficult to meet, they probably are not impossible.

One approach to the problem might be through the use of muscle potentials. Since numerous investigations (3, 4, 7, 10) indicate that muscle potentials increase as a function of the force over a fairly wide range of muscular exertion, it should be possible to substitute the potential changes for the customary scales and dynamometers. With a modern electronic amplification system for the study of muscle potentials, it would only be necessary to provide some sort of calibrated meter to register the muscle potential voltages. The meter could then provide Ss with information as to their muscular force during practice trials. During test trials, the investigator could obtain his data either from the meter or the conventional permanent record. The study here reported describes an attempt to measure the kinesthetic perception of muscular force through muscle potential changes. The Ss used made it possible to compare the apparent kinesthetic sensitivity of both male and female physical education majors and liberal arts majors.

Method

The performance studied involved a situation in which Ss were given practice in contracting the triceps brachii at an intensity necessary to generate muscle potentials of approximately 125 microvolts. Following these trials, Ss attempted to reproduce the same muscular force as measured by muscle potential output.

Apparatus. A muscle potential amplifying-integrating-recording system, designed by Dr. R. C. Davis of Indiana University, was used. The amplifier consisted of multiple stages of push-pull, resistance-capacity coupled voltage amplification. The first stage was ungrounded, and it was operated on its own battery supply. The other stages were grounded, and they shared a common battery supply. The amplifier output was fed into the integrator (5), which accumulated muscle potentials over an interval of 1/10 sec., and the integrator output drove a high-speed "Velograph" recording unit. Actual recording of the summed muscle potentials was accomplished by means of electric writing on Teledeltos paper. Since the excursions of the recording pen were proportional to the magnitude of the driving signals, the amplitude of the recorded potentials provided a measure of summed muscle potential voltages.

An electronic voltmeter, connected across the voltage amplifier output, was used to provide S with information on his muscular force. A 2-mm. strip of black tape, located at the midpoint of the meter scale, served to indicate the muscle potential level S was to generate during practice trials. In all experimental sessions, the amplifier gain controls were adjusted so that a 60-cycle 125-microvolt signal moved the voltmeter needle to the midpoint of the scale.

Connections to S consisted of a 12-x-6-x-1-cm. felt pad and a 3-mm. solder disk. The pad, saturated in saline, was secured to the right forearm by means of an elastic wrap. The disk was attached over the lateral head of the right triceps brachii by means of a strip of adhesive tape. Contact between the disk and skin was made with electrode jelly.

Procedure. The procedure in all experimental sessions was as follows: S stood in a grounded copper screen cage and faced the voltmeter located just outside the cage at approximately eye level. The purpose and procedure of the experiment were fully explained, and S was given practice in contracting the triceps brachii by simple extension of the elbow. When it was clear that the desired movement could be performed, S was given practice in moving the voltmeter needle to various points on the scale by varying the contraction force of the triceps brachii. Following the explanation and orientation period, S was given five practice trials in bringing the needle to the midpoint of the scale. Although it was seldom possible for S to hold the needle fixed on the center of the scale, it was not difficult to keep the needle movement centered about the desired point. Upon the completion of these practice trials, the meter was turned away from the cage, and S was given five test trials in reproducing the muscular force exerted during practice trials. In these trials, S used the verbal signal "Now" to indicate when the correct muscular force

was being applied. After a short rest interval, S repeated the sequence of five practice trials and five test trials. During the test trials, the integrated muscle potentials were recorded, and E marked the potential which coincided with S's verbal signal.

Scoring. In arriving at the measure of S's performance during each trial, the amplitude of the marked potential and the potential on either side of this reference was determined. These measures were converted into microvolts, and the mean of these measures constituted the trial score.

Subjects. Forty students at Indiana University served as Ss. These Ss were obtained on a volunteer basis and consisted of the following groups: (a) ten male physical education majors who were not varsity athletes; (b) ten female physical education majors; (c) ten male liberal arts majors who were not varsity athletes; and (d) ten female liberal arts majors.

Analysis of data. Performance was evaluated in terms of constant errors and variable errors. The former is a measure of performance which reveals both the magnitude and direction of error. It is equal to S's mean muscle potential minus the standard potential of 125 microvolts, and it is designated as positive or negative. The variable error provides a measure of S's precision of response. It is equal to the standard deviation of the distribution of S's scores during attempts to produce muscle potentials of 125 microvolts.

With S's classified by sex and university major groups, an analysis of variance for the two-way classification design with equal numbers of observations per subclass was performed on the error measures. This analysis made possible an evaluation of differences in performance for sex, major groups, and the interaction between sex and major groups.

Prior to collection of the data, it was decided that the 5 per cent level of confidence would constitute the critical region for rejection of the null hypothesis in all comparisons. Having accepted this class of results, no attempt was made to indicate maximum levels of significance.

An estimate of test reliability was obtained by correlation of the mean microvolt scores for the first five trials with those of the second five trials. Twenty-nine of the original 40 Ss were able to repeat the complete test within an interval of three to ten days, and these results made it possible to obtain a second estimate of test reliability.

Results

The means for constant and variable errors under each classification are reported in Table 1. Since Bartlett's test of homogeneity of variance supported the hypothesis of a common population variance for constant errors, original scores were retained in the analysis of these errors. Analysis of the variable errors was completed with a logarithmic transformation of variances as recommended by Bartlett (1). A summary of the F ratios for the two analyses is reported in Table 2.

Constant errors. It can be seen in Table 1 that the mean constant errors for all classifications of Ss were positive. Since constant errors of this sign

TABLE 1

Means of Constant and Variable Errors in Estimation of 125 Microvolts Muscle Potential for Selected Groups of Subjects

Groups	Male	Female	Combined Sexes
	Constant Errors		
Physical Education	9.75	1.05	5.40
Liberal Arts	14.75	28.05	21.40
Combined groups	12.25	14.55	
	Variable Errors		
Physical Education	23.21	22.63	22.92
Liberal Arts	24.48	22.05	23.27
Combined groups	23.84	22.34	

TABLE 2

F Values for Analysis of Constant and Variable Errors in Estimation of 125 Microvolts Muscle Potential for Selected Groups of Subjects

Source of Variance	F	
	Constant Errors	Variable Errors[1]
Major groups	7.775[2]	.277
Sex	.161	.022
Interaction	3.675	.019

[1]Analysis with logarithmic transformation of scores.
[2]Significant above the 5% confidence level.

involve "overshooting" the standard, it may be concluded that, on the average, Ss tended to reproduce more than the standard muscle potential of 125 microvolts.

The variance analysis of constant errors, as summarized in Table 2, revealed that only the variance attributable to "Major Groups" was significant. With the physical education majors (sexes combined) having a significantly smaller constant error, it may also be concluded that they were more successful than the liberal arts majors (sexes combined) in reproducing the standard muscle potential. And it would thus appear that physical education majors are more receptive to the kinesthetic stimulation of muscular exertion.

Variable errors. Analysis of the variable errors in logarithms, as summarized in Table 2, revealed no significant source of variance. With no basis for rejection of the null hypothesis in the several comparisons involved, it was concluded that Ss in one classification were about as precise (or variable) in their responses as Ss in other classifications.

Test reliability. The correlation of mean microvolt scores for the five trials with those of the second five trials for all Ss was found to be 0.501. Although a correlation of this value is statistically highly significant, it cannot be said to constitute a very high reliability coefficient. One possible cause of

this low coefficient was that the sequence of two practice-test periods frequently seemed to develop attitudes toward the task. It was not usual, for example, to have Ss speculate on their probable performance in the first test trials while completing their second practice trials. They frequently commented to the effect that their first test trials must have involved "too little" or "too much" muscular force, and such attitudes may have influenced subsequent test scores. Because of this unforeseen situation, an effort was made to have Ss repeat the entire test.

The correlation of the mean microvolt scores for the first test day with those of the second test day for 29 Ss was found to be 0.862. A correlation of this value is statistically highly significant, and it can be said to constitute a reasonably satisfactory reliability coefficient. It is suggested that this coefficient is probably more representative of test reliability.

Discussion

In regard to the major purpose of this investigation, the use of muscle potentials appears to offer definite promise in tests of the kinesthetic perception of muscular force. The technique eliminates tactual stimulation and provides objective scores of performance. Judging from the comments of Ss, it also appears to offer an interesting and challenging task.

In evaluating both the general technique of utilizing muscle potentials in kinesthetic tests and the particular procedures of this investigation, the following limitations and problems should be recognized.

(*a*) The magnitude of potentials picked-up from skeletal muscles will vary with: 1. size of electrodes; 2. type of electrodes; 3. arrangement of electrodes; 4. positioning of electrodes; and 5. cross-sectional area of muscle (2, 4). Because of differences in these factors, the muscle potential data of one experiment may not be directly comparable to that of another experiment. In a single experiment, of course, the first three factors are not difficult to control, but the inevitable differences in the positioning of electrodes and the cross-sectional area of muscle will probably result in individual Ss working at somewhat different levels of muscular force in generating potentials of a standard magnitude. This seemingly unsatisfactory state of affairs probably occurred in the investigation here reported. It should be noted, however, that the situation is not unique to the technique of using muscle potentials in kinesthetic tests. Without attempting to minimize the situation, it can be said that the more conventional tests of the kinesthetic perception of muscular force possess a similar shortcoming. This will be noted in a later section of these comments.

(*b*) Although it is quite clear that the magnitude of muscle potentials increase as a function of muscular force, it must not be expected that a group of individuals will each generate potentials of the same magnitude for any given muscular force. Ss, for example, will not generate potentials of the same magnitude when exerting the same force on a dynamometer or any similar device for the measurement of muscular force. In understanding this

apparent discrepancy, it is only necessary to recall that dynamometers and such devices simply provide measures of the effectiveness of skeletal muscle in operating the body levers and overcoming resistance. The conventional strength measures, in short, do not provide direct measures of the actual force in any muscular effort.

For any individual in any given strength test, there will be a constant relationship between muscular forces and strength meaures, but it does not follow that the relationship will be the same for all individuals. Individual differences in the mechanical advantage of body levers, internal friction of moving parts, and the action of antagonistic muscles will make it almost certain that different individuals will exert different amounts of muscular force to attain the same strength measure. Since muscle potentials are directly related to muscular force, individuals cannot be expected to generate potentials of the same magnitude while registering the same force on a dynamometer or any similar device. While there may be some individual differences between the magnitude of muscle potentials and actual muscular force, these differences are independent of the mechanical advantage of lever systems, internal function, and antagonistic muscular action.

It should also be evident that there is no justification for assuming a common level of muscular exertion in the conventional tests of kinesthetic perception. Requiring Ss to produce and reproduce a standard force on a dynamometer, for example, will inevitably result in their working at different levels of muscular exertion. This aspect of kinesthetic testing appears to have been generally ignored.

(*c*) Although Ss appeared to experience no great difficulty in keeping the needle movement centered about the desired scale point during practice trials, it was felt that the meter sensitivity probably made the task more difficult than necessary. In future applications of the technique, it might be desirable to reduce needle fluctuations by meter damping. This procedure, of course, would render the meter less sensitive to the continuous small changes in muscular force, but any loss in sensitivity could certainly be kept below levels perceptible to S.

It has also been suggested that the problem of needle fluctuation might best be resolved by having a meter record the voltage changes across the output of a muscle potential integrator.[1] With an integrator which continuously accumulates and leaks, the output changes would be less rapid.

(*d*) The decision to base measures of kinesthetic performance on a .3 sec. sample of integrated muscle potentials was more or less arbitrary, and a longer interval may prove desirable. Measurements over a longer interval would possibly improve test reliability.

Conclusions

The use of muscle potentials appears to offer definite promise in the development of tests for the kinesthetic perception of muscular force which are

[1]Personal communication from Dr. R. C. Davis.

free of tactual stimuli. The technique provides for objective performance scores, and Ss seem to find the general procedures both interesting and challenging.

From the preliminary evidence collected on the kinesthetic sensitivity of selected groups of male and female physical education majors and liberal arts majors, it was concluded that:

1. All groups, on the average, tended to reproduce more than the standard muscular force as represented by 125-microvolt potentials.
2. The difference in constant errors between sexes was not significant, but the constant error for physical education majors was significantly smaller than that for liberal arts majors.
3. The differences in variable errors between sexes and between major groups was not significant.

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Measurement of Stress Evidenced by College Women in Situations Involving Competition

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Abstract

The purpose of this study was to investigate the alarm reaction and resistance stages of emotional stress through measurement of the eosinophil count and cardio-respiratory symptoms in a group of college women subjected to a variety of competitive experiences. It was concluded that stress may be elicited by 1. anticipation of a stressor situation, 2. participation in a stressor situation, or 3. denial of expected participation in a stressor situation. In each instance, the stress elicited in individuals 1. varies from situation to situation, 2. is related to the psychological components in the stressor situation to a far greater degree than it is related to the components involving physical activity, and 3.. is related to identifiable differences in past experiences which are relevant to the situation.

STRESS IS a complex term with many meanings. Recently, it has been utilized by physiologists to describe a total bodily reaction to any situation or agent which tends to destroy the homeostatic balance. In this context, Hans Selye (9, 10) has described stress as the sum total of all non-specific biological phenomena, including damage and defense. This "effort for equilibrium" concept of stress has been utilized in much of the research done in this area during the past decade. It is with this meaning that the term "stress" is used in the present study.[1]

Physiological stress resulting from homeostatic upset may be caused by either psychological or physiological agents or conditions operating within an external environment which is physically definable, an internal environment of physiological structure and function and the social evironment which surrounds the occurrence and gives meaning to it. Sands and Rodnick (8, *p. 673*) have emphasized the insurmountable complexity of the conceptual schema required to include all of the individual mechanisms necessary to account for the behavior of the organism at any given time. Consequently, it has so far been necessary to study stress in terms of one or more discrete mechanisms which can be isolated in this integrated complex rather than to investigate the phenomenon of physiological stress as an integrated whole.

[1]This study was made in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School, University of Southern California, 1956, under the direction of Dr. Eleanor Metheny. For their enthusiastic co-operation in facilitating collection of data, special appreciation is extended to Dr. Caroline B. Sinclair, the staff of the physical education department, and the participating students of Madison College.

The isolation of discrete mechanisms related to the totality of the integrated adaptive processes provides a convenient, although limited, approach to the understanding of the ways in which an organism reacts to the stressors encountered. The conclusions drawn from such partial knowledge can be related specifically only to the special frame of reference within which they were derived. However, these specific findings do provide basis for further speculation and better insight into the nature of the total problem, and when combined with specific conclusions drawn from other similar studies their importance in establishing a basis for generalization about the total process is enhanced.

The precautions concerning generalization from discrete information must be doubly emphasized in relation to the study of emotional stressors. Stress caused by emotion may be dealt with either in terms of psychoanalytic theory or neurophysiologic theory. Each frame of reference has value, but a sound basis for explaining psychiatric interpretations in physiological terms or neurophysiological findings in psychoanalytic terminology has not yet been established. Hope for the eventual unification of understanding of all qualitative and quantitative phenomena related to emotionally derived stress is held by physiologists and psychologists alike, but such an integrated interpretation must wait on an extension of scientifically supported information in both areas. Many specific aspects of the total adaptive process must be studied before general concepts can be formulated; and studies of the quantitative nature of reactions are needed before the qualitative concepts can be fully understood.

The greatest amount of work to date has been done in the area of quantitative measurement of symptoms of physiological adaptation to stressful situations. It has long been established that the secretions of the adrenal cortex are increased during stress. However, since this endocrine gland has no duct, it is difficult to obtain any direct measure of the amount of secretion in the intact organism. Accordingly, it has been necessary to study secondary changes in adrenal cortical secretion in order to obtain an indirect measure of the activity of the adrenal cortex. Work output, cardio-respiratory change, temperature change, reaction time, and harmone assay have all been utilized as secondary measures of the organism's adaptation to stress. Each approach has produced useful, but partial, information.

In recent years much interest has centered around the work of Thorn (11), Dalton and Selye (2), Recant (7), and others who have pointed out the direct relationships between the adrenal cortical hormone secretions and the number of circulating eosinophils in the blood. They have demonstrated that this relationship provides an easily obtainable secondary measure of adrenal cortical secretions and a tertiary measure of stress. In various forms, the eosinophil count approach has been used to investigate many specific aspects of the human organism's adaptation to stressful situations. This approach has provided kinds of information about the physiological response of the organism in emotionally charged situations which were not readily

obtainable from studies of work output and cardio-respiratory response. It has opened up new possibilities for investigation of the relationships between emotional phenomena and physical performance. This approach was utilized in the present study to examine stress reactions to competitive situations involving sports performance and written examinations such as occur in a school setting. Selected cardio-respiratory symptoms were also used as supplementary measures of stress.

Purpose

It was the purpose of this study to investigate the alarm reaction and resistance stages of emotional stress through measurement of eosinophil count and cardio-respiratory symptoms in a group of college women subjected to a variety of competitive experiences.

Specifically, the study was concerned with: 1. two groups of subjects classified according to experience and lack of experience in "varsity" type sports competition; 2. five situations in which subjects anticipated participation, including a class situation, intramural situation, interscholastic situation, written test, and spectator situation; 3. five situations in which the subjects' expectation of participation was fulfilled; 4. four situations in which the subjects did not do the activity they had anticipated.

In each anticipatory situation the eosinophil count, pulse rate, and respiration rate were studied as quantitative measures of adaptive reactions to stress. One hour and four hours after the anticipated participation had occurred or failed to occur, the eosinophil count was taken as a quantitative measure of post stressor adaptation. All measures were converted to stress scores by subtracting the measurement obtained in the experimental situation from the corresponding average base measure obtained under near basal conditions. These basic data were examined with reference to: 1. evidence of differential levels of adaptive anticipatory response to stressors of potentially different intensities; 2. evidence of differential levels of adaptive post-stressor response to stressors of potentially different intensities; 3. evidence of differential levels of adaptive post-stressor response in situations where the anticipated activity had been carried out and those in which it had not; 4. evidence of differential levels of stress in subjects who were "experienced" and those who were "inexperienced" with regard to "varsity" type athletic competition.

Subjects

A total of 28 subjects was used. All were women and all were students at Madison College, Harrisonburg, Virginia. The range in age was from 17 to 21 years, and the academic standings ranged from Freshmen through Junior.

Each subject was enrolled in the regular college physical education course in basketball and, in addition, had voluntarily associated herself with the intramural basketball program sponsored by the college athletic association.

The subjects were in a state of good health. Each subject was given a complete physical examination by the resident medical doctor, who certified that she was free from allergy and infection, and had his approval to participate in the college basketball program.

Fourteen of the subjects were members of the Madison College interscholastic basketball team. This team was picked on the basis of individual excellence in tactics and technique with regard to basketball. The team members practiced together for six weeks and then played a five-week schedule of games, one being played each week. These subjects were called the "experienced" group with reference to their "varsity" type athletic experience.

The remaining 14 subjects had no experience in "varsity" type athletics in college, high school, or other athletic sponsoring organizations. They were called the "inexperienced" group with reference to their lack of "varsity" type athletic experience.

No known systematic factor other than those described operated as a selective influence, and therefore the group is assumed to represent a random sample from the population of women students interested in basketball at Madison College.

Experimental Design

The subjects were studied with respect to three conditions, five situations and two circumstances. The establishment of these variables constituted the experimental design.

CONDITIONS

The variable conditions included base, anticipatory, and post stressor.

Base Condition. Each subject was asked to report to the laboratory the first time and it was explained to her that she was to take part in an experiment which dealt with red blood cell counts and the effect of exercise. No mention was made of the term emotion and the subject was not told at what times she would be tested. It was further explained that about 18 blood samples were to be drawn over a four-month period of time. No subject suspected the real nature of the experiment. The blood sample was drawn as suggested by Bonner and Homburger (1) in the afternoon of a day when there was no reason to suspect that the external college environment had been anything but "normal." Random questioning of the subjects regarding tests and personal problems of magnitude revealed no extreme trauma of an emotional nature. The pulse rate and respiration rate were also noted. The base condition was determined on three different occasions and these three scores were totaled and a mean score was calculated which was called the base score.

Anticipatory Condition. Before the experimental situation was encountered, the subject was informed that she would participate in the approaching situation. No attempt was made to "overemphasize" the importance of the coming situation, and the announcement was made as it usually was with regard to coming activities and tests. The physiological counts were made immedi-

ately before the anticipated event and at no time was the count made more than 15 minutes before the expected participation.

Post-Stressor Condition. The subject was asked to report to the laboratory one hour after the experimental situation and four hours after the experimental situation. Physiological counts were obtained at those times.

SITUATIONS

The variable situations included class, intramural, interscholastic, written test, and spectator.

Class Situation. The anticipated basketball game was announced the previous class period. Each girl realized that her grade was in some small way related to the excellence of her playing ability. The subjects were members of organized teams within their class and had played together for at least five weeks. They were directed by the teacher as to techniques and playing opportunities before the game situation, but they knew that they would have no direction other than officiating during the actual playing time.

Intramural Situation. The anticipated intramural game had been posted at the beginning of the basketball season. Each subject was a member of an intramural team which had been organized according to dormitory residence, and the subject had some loyalty to that particular group by virtue of her residence and interest. The teams were student-coached and the games were student-officiated. A tournament was in progress and each team was attempting to win in its league, so that it might be in the final tournament. No rewards other than satisfactions were involved.

Interscholastic Situation. The anticipated interscholastic game had been announced at the beginning of the practice period, about three months before the game was played. The team was coached by a regular member of the physical education staff and was officiated by national officials of the Women's National Officials' Rating Committee. Although the competition was keen, the social aspects of the game played a large role in the situation. A long-time attitude had been built which emphasized that excellence in play was more important than winning or losing. The atmosphere was conducive to maintenance of standards established by the National Section for Girls and Women's Sports.

Test Situation. The written test was a "normal" test situation for a college class. The students prepared themselves to take a regular written test in history, camp leadership, or recreational sports rules. The tests were part of the regular college work required in the course, and the test was emphasized by the teacher according to his or her belief regarding the importance of written testing. No effort was made to determine the subject's grade in that class before the test, but it was ascertained that in no case was any subject failing the course; nor was it possible for the subject to fail the course by virtue of a failure in the written test situation used in the experiment.

Spectator Situation. As a requirement in their own basketball class, the subjects were asked to attend a basketball game as a spectator. The two games

used were the final game which determined the school championship in the intramural basketball program and the exhibition game played between the intramural championship team and the interscholastic team. The subjects were instructed to go to either game.

CIRCUMSTANCES

The variable circumstances included participation or non-participation in the anticipated activity. In the cases of the class, intramural, interscholastic, and test situations, one-half of the subjects in each group did what they anticipated doing, while the other half did not. The subjects were assigned to participate or not participate at random in the first situation. After that participation and non-participation were alternated for the remaining situations. The written test was left for last, since failure to administer an announced test was an unusual procedure.

Measurement Techniques

The blood sample was taken from the tip of the finger by puncturing the skin with a lancet and drawing blood into a white blood corpuscle pipette. In the pipette was also drawn a propylene glycol diluent, as described by Randolph (5, 6) and recommended by Henneman, Wexler, and Westenhaven (4). In this experiment a 1:20 dilution was used, and all counts were made within three hours of the time taken. The eosinophils were counted in a Speirs-Levy counting slide designed primarily for doing direct eosinophil counts in blood. The eosinophils were then counted by using a microscope with a mechanical stage, bifocal, with a 15x wide field. The field of vision included one square millimeter area.

The pulse rate was taken at the radial artery by manual count. The count was made every 15 seconds until three consecutive counts with the same rate were obtained.

The respiration rate was taken by observation. Repeated 15-second counts were taken until three consecutive counts with the same rate were obtained.

Data

The difference between the anticipatory score and the average base score was labeled anticipatory stress score and the difference between the four-hour post stress count and the base count was labeled *post-stressor stress score.* Similarly, post-stressor scores were calculated for the data obtained one hour after the stressor situation. Later, these scores were discarded, since at no time did the one-hour drop exceed the four-hour drop.

Analysis of Data

The ranges and means for the eosinophil counts, the pulse rate and the respiration rate obtained under base, anticipatory, and post-stressor conditions are summarized in Table 1.

The stress scores were arranged to permit analysis of variance utilizing the design advocated by Edwards (3) for repeated measures of the same subjects. The data were organized for analysis with reference to the variables

TABLE 1
Ranges and Means for Eosinophil, Pulse, and Respiration Raw Scores

	Base Condition
Eosinophils	100-410 (208.00)
Pulse	64-88 (75.50)
Respiration	12-24 (18.35)

	Anticipatory Condition				
	Class	Intramural	Interscholastic	Test	Spectator
Eosinophils	90-370 (190.35)	100-390 (187.85)	60-250 (113.84)	50-290 (130.71)	110-400 (210.00)
Pulse	64-92 (81.57)	64-92 (82.71)	80-88 (86.15)	68-88 (83.85)	64-80 (75.00)
Respiration	16-28 (21.42)	16-28 (22.00)	24-28 (24.30)	16-28 (23.57)	16-20 (18.14)

	Post-Stressor Condition				
	Class	Intramural	Interscholastic	Test	Spectator
Eosinophils	60-270 (142.50)	40-310 (123.92)	20-100 (47.69)	10-190 (63.67)	20-280 (79.64)
Pulse	64-80 (73.71)	64-84 (76.85)	68-80 (73.53)	64-80 (73.85)	64-80 (73.85)
Respiration	12-20 (16.85)	12-24 (18.28)	16-20 (17.23)	12-24 (17.71)	16-24 (18.14)

of groups, situations, and conditions. Null hypotheses were formulated with reference to the stress scores, the variables, and the interaction among the variables. The first group was concerned with the statistical significance of the stress scores as such. The second set was concerned with the differences between groups in comparable situations. The third set dealt with differences among stress scores obtained in the several situations. The circumstance of participation or non-participation as a variable was not considered in the analysis of anticipatory stress, since at that stage of the experiment all the subjects believed that they would do as anticipated. Fisher's t for correlated means was used to test differences between pairs of cell means when statistical significance was shown by the F test. For both F and t, the 1 per cent level of confidence was accepted as indicating statistically significant differences. A small number of differences significant at the 2, 3, and 4 per cent level were also noted, when it was apparent that they fitted the general pattern established by the 1 per cent level findings.

In the base condition, the range of eosinophil counts was 100-410 with a mean of 208, of pulse rate 64-68 with a mean of 75.5, and of respiration rate 12-24 with a mean of 18.4.

Anaylses of the statistically significant findings with reference to the eosinophil data are presented in Tables 2, 3, 4, 5, 6, 7, and 8.

TABLE 2
Schematic Analysis of Means of Eosinophil Stress Scores Obtained for Four Sub Groups in Five Situations

Groups / Situations	"Experienced" Participating	"Experienced" Non-participating	"Inexperienced" Participating	"Inexperienced" Non-participating
Class		P	AP	AP
Intramural	P	P	AP	AP
Interscholastic	AP	AP		
Written test	AP	AP	AP	AP
Spectator	P	P	P	P

Key:
A—The mean of the anticipatory stress score was statistically significant.
P—The mean of the post-stressor stress score was statistically significant.
This table is to read as follows:
When the mean eosinophil stress scores in the class situation were compared with their own standard errors, 1. neither of the stress scores found in the "experienced" participating group was statistically significant, 2. the post-stressor condition mean was statistically significant for the "experienced" non-participating group, and 3. both the anticipatory and post-stressor condition means were satistically significant for the "inexperienced" participating and "inexperienced" non-participating groups.

TABLE 3
Anticipatory Eosinophil Stress Scores

Situations	Mean	S. D.	t	Level of Confidence
		"Experienced" Group		
Class	—8.36*	3.54	2.36	—
Intramural	1.64	4.21	0.38	—
Interscholastic	72.54	7.45	9.74	1%
Written test	75.92	8.39	9.06	1%
Spectator	—4.07*	4.61	0.88	—
		"Inexperienced" Group		
Class	47.42	3.39	13.98	1%
Intramural	63.86	2.98	21.43	1%
Written test	83.14	8.84	9.40	1%
Spectator	3.86	3.92	0.98	—

*Indicates that anitcipatory score was lower than base score.

ANTICIPATION STRESS

Statistically significant evidence supports the following statements:

1. Anticipatory stress is evidenced by the "experienced" group in the interscholastic and test situations and by the "inexperienced" group in class, intramural and test situations.
2. The "inexperienced" group had greater stress scores than the "experienced" group in all situations involving basketball.
3. When situations were compared within group scores, differential levels of adaptive anticipatory response to stressors of potentially different intensities were found.
   (a) For the "experienced" group, these levels were, in descending order,

TABLE 4
Post-Stressor Eosinophil Stress Scores

Situations	Means	S. D.	t	Level of Confidence
		"Experienced" Group		
Class	46.35	12.73	3.64	1%
Intramural	62.35	5.08	12.27	1%
Interscholastic	85.35	20.67	4.12	1%
Written test	147.42	16.59	8.89	1%
Spectator	127.42	15.61	8.16	1%
		"Inexperienced" Group		
Class	89.57	3.71	24.14	1%
Intramural	108.86	6.13	17.76	1%
Written test	147.43	10.31	14.29	1%
Spectator	127.42	14.65	8.69	1%
		"Experienced" Participating Group		
Class	12.57	5.97	2.11	—
Intramural	63.57	7.19	8.84	1%
Interscholastic	95.43	6.40	14.91	1%
Written test	186.43	26.19	7.12	1%
		"Experienced" Non-participating Group		
Class	80.71	17.91	4.51	1%
Intramural	61.14	7.44	8.22	1%
Interscholastic	170.84	28.26	6.04	1%
Written test	102.57	6.93	14.80	1%
		"Experienced" Participating Group		
Class	94.71	5.49	17.21	1%
Intramural	127.28	7.06	18.08	1%
Written test	144.71	11.09	13.05	1%
		"Inexperienced" Non-participating Group		
Class	84.42	4.27	19.77	1%
Intramural	90.42	2.78	32.52	1%
Written test	150.14	18.38	8.17	1%

written test, interscholastic, and an undifferentiated group of class, intramural, and spectator.

(b) For the "inexperienced" group, the differential levels were, in descending order, written test, intramural, class, and spectator.

4. The cardio-respiratory findings supported the eosinophil data.

POST-STRESSOR STRESS

Statistically significant evidence supports the following statements:

1. Post-stressor stress occurs in relation to all of the stressor situations, ex-

TABLE 5

Schematic Analysis of Differences Between Means of Anticipatory Eosinophil Stress Scores for Groups Observed in Five Situations

Situations \ Groups	"Experienced"	"Inexperienced"
Intramural—Class	No difference	Intramural
Written test—Class	Written test	Written test
Spectator—Class	No difference	Class
Interscholastic—Class	Interscholastic	
Intramural—Written test	Written test	Written test
Intramural—Spectator	No difference	Intramural
Interscholastic—Intramural	Interscholastic	
Written test—Spectator	Written test	Written test
Interscholastic—Written test	Written test	
Interscholastic—Spectator	Interscholastic	

This table is to read as follows:
When anticipatory stress scores for the class and intramural situations were compared, 1. no difference was found for the "experienced" group, and 2. the intramural scores were higher than the class scores for the "inexperienced" group.

TABLE 6

Comparison of Anticipatory Eosinophil Stress Scores of Groups in Varous Situations

Situations	Difference Between Means	t	Level of Confidence
"Experienced" Group			
Class—*Intramural*[1]	5.71	0.91	—
Class—*Test*	81.43	7.37	1%
Class—Spectator	5.42	1.14	—
Class—*Interscholastic*	80.71	12.75	1%
Intramural—*Test*	75.00	8.22	1%
Intramural—Spectator	2.43	0.34	—
Intramural—*Interscholastic*	70.71	9.50	1%
Test—Spectator	80.50	6.99	1%
Test—Interscholastic	12.14	5.84	1%
Spectator—*Interscholastic*	71.43	9.12	1%
"Inexperienced" Group			
Class—*Intramural*	19.14	4.82	1%
Class—*Test*	44.28	7.18	1%
Class—Spectator	44.28	8.98	1%
Intramural—*Test*	28.43	5.22	1%
Intramural—Spectator	60.00	12.02	1%
Test—Spectator	79.28	7.76	1%

[1]The situation which elicited the larger mean stress score is italicized.

cept that in which the "experienced" group participated in the class situation.

2. The "inexperienced" group had consistently higher stress scores than the "experienced" group in all comparable situations involving basketball.
3. When situations were compared within group scores, differential levels

TABLE 7

Schematic Analysis of Differences Between Means of Post-Stressor Eosinophil Stress Scores for Sub Groups Observed in Five Situations Under Conditions of Participation and Non-Participation

Groups / Situations	"Experienced"		"Inexperienced"	
	Participating	Non-participating	Participating	Non-participating
Intramural—Class	Intramural	Class[3]	Intramural[1]	Intramural
Interscholastic—Class	Interscholastic	Interscholastic		
Written test—Class	Written test	Written test	Written test	Written test
Spectator—Class	Spectator	Spectator	Spectator	Spectator
Interscholastic—Intramural	Interscholastic	Interscholastic		
Written test—Intramural	Written test[1]	Written test	Written test	Written test
Intramural—Spectator	Spectator	Spectator	Spectator	Spectator
Interscholastic—Written test	Written test	Interscholastic[3]		
Interscholastic—Spectator	Spectator	Spectator		
Written test—Spectator	Written test[1]	Written test	No difference	No difference

[1]2% level of confidence
[2]3% level of confidence
[3]4% level of confidence

This table is to be read as follows:

When the post-stressor stress scores for the class and intramural situations were compared, 1. the intramural scores were higher than the class scores for the "experienced" participating group, the "inexperienced" non-participating group, 2. the class scores were higher than the intramural scores for the "experienced" non-participating group.

of adaptive post-stressor response to stressors of potentially different intensities were found.

(a) For the "experienced" group, when participation in the anticipated situation had occurred, the differential levels of post-stressor stress were, in descending order, written test, spectator, interscholastic, intramural, and class.

(b) When participation in the anticipated situation had *not* occurred, the differential levels were, in descending order, interscholastic, written test, spectator, class, and intramural.

(c) and (d) For the "inexperienced" group (both participating and non-participating), these differential levels of post-stressor stress scores were, in descending order, written test, spectator, intramural and class.

4. With reference to participation or non-participation in the anticipated basketball stressor situations:

(a) In the "experienced" group, higher stress scores were indicated for those who were not permitted to participate.

(b) In the "inexperienced" group, higher stress scores were indicated for those who did participate.

Conclusions

With reference to events which are a normal part of the educational experiences of college women, stress may be elicited by 1. anticipation of a stressor situation, 2. participation in a stressor situation, or 3. denial of expected par-

TABLE 8
Comparison of Post-Stressor Eosinophil Stress Scores of Participating and Non-Participating Groups

Situations	Difference Between Means	t	Level of Confidence
	"Experienced" Group		
Participation			
Class—*Intramural*[1]	51.00	7.99	1%
Class—*Interscholastic*	82.86	33.41	1%
Class—*Test*	173.86	6.66	1%
Class—*Spectator*	74.28	6.97	1%
Intramural—Test	94.28	3.68	1%
Intramural—*Interscholastic*	31.86	5.76	1%
Intramural—*Spectator*	107.14	5.05	1%
Interscholastic—*Test*	91.00	4.38	1%
Interscholastic—*Spectator*	21.43	6.51	1%
Test—Spectator	15.71	3.54	2%
Non-participation			
Class—Intramural	34.71	3.06	1%
Class—*Interscholastic*	104.28	8.89	1%
Class—*Test*	45.57	4.42	1%
Class—*Spectator*	90.00	8.24	1%
Intramural—*Test*	37.14	5.77	1%
Intramural—*Interscholastic*	123.85	5.72	1%
Intramural—*Spectator*	34.28	3.83	1%
Interscholastic—Test	88.14	4.18	1%
Test—Spectator	24.28	4.25	1%
	"Inexperienced" Group		
Participation			
Class—*Intramural*	33.43	4.70	1%
Class—*Test*	50.00	5.48	1%
Class—*Spectator*	54.28	4.15	1%
Intramural—*Test*	23.14	2.73	4%
Intramural—*Spectator*	40.00	4.10	1%
Test—Spectator	24.28	2.23	—
Non-participation			
Class—*Intramural*	12.57	3.68	2%
Class—*Test*	68.57	4.77	1%
Class—*Spectator*	58.57	4.27	1%
Intramural—*Test*	61.14	3.56	2%
Intramural—*Spectator*	58.57	4.57	1%
Test—Spectator	41.43	2.28	—

[1]The situation which elicited the larger mean stress score is italicized.

ticipation in a stressor situation. In each instance, the stress elicited in individuals 1. varies from situation to situation, 2. is related to psychological components in the stressor situation to a far greater degree than it is related to the components involving physical activity, and 3. is related to identifiable differences in past experiences which are relevant to the situation.

Conjectures

Analysis of the experimental data suggested several hypotheses which seem tenable but which have not been experimentally validated. These theories suggest leads for further experimentation which might clarify the complex physiological-psychological relationships in the phenomenon of stress.

1. Psychological reinterpretation of a stressor may result in physiological adjustment which fosters homeostasis.

2. Exercise, while imposing a stress, may also act as a homeostatic regulator of the body with regard to the resolution of physiological reactions elicited by emotional stressors.

3. Repeated exposure to a specific stressor situation which can be resolved either by physical activity or psychological reinterpretation may raise the individual's threshold for stress in subsequent exposures to the same or similar stressor situations.

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Notes & Comments

NOTES

Comparison of Three Manuometers

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THREE MANUOMETERS, purchased from two manufacturing concerns, were compared by testing the right grip strength of 34 randomly selected college male students with each instrument. In this testing, the order in which the manuometers were used by the subjects was rotated in a Latin square arrangement, so as to equalize any fatigue effect or learning advantage which may have been present in the testing situation.

The means and standard deviations for the three instruments, A, B, and C, were as follows:

	A	*B*	*C*
Means	124.1	135.8	102.8
Standard Deviation	15.1	21.1	17.1

From this, it will be seen that differences exist between the means of the three instruments on the same test with the same subjects. The differences, with correspondnig t ratios, were:

	Dm	*t*
Instruments A and B	11.7	.79
Instruments A and C	21.3	2.66
Instruments B and C	33.0	2.63

Except for A and B, these differences are statistically significant at the .01 level of confidence.

The distributions of scores also differ, as indicated by the standard deviations. The coefficients of relative variability (V) are:

	V
Instrument A	12.2
Instrument B	15.5
Instrument C	16.6

The contrast in relative variability between instruments B and C is not great, although for absolute variability it is four pounds, or approximately 25 per cent. However, the contrast with instrument A is considerable: 27 per cent less than for instrument B and 36 per cent less than for instrument C.

The experience described in this investigation, while not intended as a method of calibration, does indicate the need for checking the calibration of even mechanical instruments when using them in strength-testing procedures.

Hygiene of Menstruation

A study of policy and practice in selected schools in New York State[1]

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THIS STUDY is an inquiry into policy and practice in teaching hygiene of menstruation in seventh, eighth, and ninth grades in 12 selected schools in a metropolitan and a suburban area in New York State. The state syllabus makes no specific provision for teaching this subject. The majority of the children attending the six city schools studied may be presumed to come from homes where parents are not high school graduates, where both parents work; a sizable minority comes from homes where a foreign language is spoken. The total number of girls in these six schools is approximately 4,500. The six suburban schools are in middle-class communities. In these schools many children presumably come from homes where one or both parents are college graduates. The number of girls in these schools is approximately 1,400.

Data were gathered by interviews with school personnel conducted by graduate students trained in interviewing. The principal of each school indicated those members of his staff, teachers of physical and health education, general science, or homemaking, as well as doctors and nurses, who were concerned with teaching or guidance in the hygiene or physiology of menstruation.

The interview was designed to answer the following questions concerning the hygiene and physiology of menstruation: Is the subject regularly included in the course of study? Where? How consistently? What is the content? What time is spent? What audio-visual aids are used? What, if any, factors operate to prevent inclusion or full discussion? The interview was partly structured and partly unstructured. Data were recorded on a printed questionnaire form during and after the interview; they were tabluated and analyzed by the authors.

Analysis of the interview questionnaires revealed the following:

1. Most children attending the six city schools were not exposed to teaching in this area. It appeared *likely* that most children in two of these schools would receive some instruction; this conclusion was based on the observation that in one school two health education teachers out of five regularly included it in their course and one included it if it was student initiated; in the other school one of the two health education teachers included it regularly and one on student initiative. In two other city schools it was *unlikely* that students would receive instruction; it was only included on student initiative by some teachers and not included at all by others. *No program* of instruction appeared to exist in two schools. Instruction was, for the most part, brief; of the 11 teachers who stated they handled the subject, eight reported they spent one-half hour or less. The interviewer recorded nine instances in which specific pamphlets were mentioned as teaching aids.

2. Most children in the six suburban schools were exposed to some teaching in this subject. In five schools it was *assured* that most children receive some instruction. A school was included in this *"assured"* category if the teacher who included it *regularly* taught a great many classes, even if the subject was student initiated by others. In one school there appeared to be *no program*. The subject was most commonly handled in homemaking courses. Of the 13 teachers in these schools who handled the subject, nine stated that they spent one or more periods on the topic. Specific pamphlets were mentioned as aids 27 times.

[1]This study was partially supported by a grant from Personal Products Corporation.

TABLE 1

Instruction in the Hygiene of Menstruation in Grades 7–9 in six City Junior High Schools and in two Junior High and four Senior High Schools in Suburban Communities in New York State

Schools	Classroom Coverage												Over-all Coverage			
	Homemaking				Heath and Physical Education				General Science							
	Regularly included	Incidental	Not included	No. teachers interviewed	Regularly included	Incidental	Not included	No. teachers interviewed	Regularly included	Incidental	Not included	No. teachers interviewed	Assured	Likely	Unlikely	No program
City schools																
A			2	2		1	1	2							X	
B					2	1	2	5						X		
C					1	1		2		1		1		X		
D			1	1		1	2	3			1	1			X	
E							1	1			2	2				X
F[1]																X
Total	0	0	3	3	3	4	6	13	0	1	3	4	0	2	2	2
Suburban								1					X			
G					1								X			
H	1			1			1	1								X
I							1	1								
J	2			2				3					X			
K	2	1		3	2	1							X			
L	2			2							1	1	X			
Total	7	1	0	8	3	1	2	6	0	0	1	1	5	0	0	1
TOTAL (City and Suburban)	7	1	3	11	6	5	8	19	0	1	4	5	5	2	2	3

[1]Information from principal.

3. Widest possible variations in classroom treatment occurred within a single school. They varied in both city and suburban schools from purposeful omission to relatively thorough classroom discussion with films and pamphlet distribution.

4. The omission of the subject from the state syllabus was mentioned by 11 of the 20 teachers in the city schools and by one of the 15 in the suburban as a "problem" related to classroom treatment.

5. The question of "legality" was raised by 12 city and three suburban teachers.

A brief inquiry was made to determine what information on this subject 239 students, in the suburban school with the most complete coverage, possessed. The results of a multiple-choice questionnaire of 25 questions on health including seven on menstruation indicated that the students, who had been exposed to from one to three years of a relatively good program, possessed considerable misinformation and lack of information. Only 19 per cent of the seventh and 30 per cent of the ninth grade students knew that the origin of the blood released in menstruation is "the uterus (womb)." Sixteen per cent of the seventh graders and 27 per cent of the ninth graders knew that the flow of blood "was an indication that the special lining of the uterus prepared for pregnancy is being expelled." These students did, however, reveal wholesome attitudes about menstruation. The variance of scores of seventh and ninth grade students on questions of health other than menstruation are significantly different. The fact that they are not significantly different on menstruation may reflect the inadequacy either in depth or extent of the program despite the fact that it was the best program studied.

Professional Preparation of Athletic Coaches in the Public Schools of Minnesota[1]

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AT THE TIME this study was made, there were no certification requirements for coaches in Minnesota. The study was undertaken to determine what formal preparation had been obtained by persons now coaching in Minnesota, and to determine what the coaches themselves, as well as school superintendents, believed the essential functions and competencies of the athletic coach should be.

Recommended competencies for athletic coaches seemed to fall into three general categories: Instruction, Organization and Management, and School and Community Relationships (Personal and Professional).

A questionnaire was developed to determine whether school superintendents and coaches in the field believed the competencies listed were essential, desirable, or non-essential to successful inter-scholastic sport coaching.

In order that all concerned might have an opportunity to express themselves, and in order to secure a large sample of opinions, it was decided that all superintendents of school systems maintaining senior high schools in Minnesota, and all coaches of football, basketball, and men who coached both sports, would be included in the study.

Four hundred fifty-seven questionnaires were sent to school superintendents, of which 315 were returned (69%); 322 questionnaires were sent to basketball coaches, and 318 (99%) returned; 305 were sent to football coaches, and 297 (97%) returned; 197 were sent to coaches of both football and basketball, and 172 (87%) returned. One hundred sixty-six assistant coaches voluntarily returned completed questionnaires.

Of the coaches surveyed, 428 held majors in physical education, 160 held minors, and 170 coaches had no training in the field of physical education. The pattern of responses to the questionnaire shows that the majority of both superintendents and coaches agree

[1]Copies of the complete study may be obtained upon request from J. G. Neal, Supervisor, Health, Physical Education, Safety and Recreation, Minnesota Department of Education, 333 State Office Building, St. Paul 1, Minnesota.

that almost all of the competencies listed were essential. Those who did not list the competency as essential almost unanimously regarded it as desirable.

Essential Competencies

The competencies checked as essential most frequently by both school superintendents and coaches who participated in the questionnaire study are listed below.

The athletic coach should be qualified to plan an athletic program based on understanding the pupil including: the basic principles of sequential patterns of child growth and development; the significance of individual differences in children and youth; the nature of the learning process in relation to physical education; the knowledge, skills, and abilities developed through the elementary and secondary school physical education program.

He should understand the relation of physical education, including athletics, to the purposes and objectives of education in American democracy including: the fundamental inter-relatedness of the instructional (required and elected) program in physical education; the intramural program; the interscholastic activities program in meeting diverse needs of pupils.

He should provide learning experience in motor activities such as: understanding the significance of the teacher as an influence on the attitudes and behavior of the pupil; ability to improve his total fitness in regard to appearance, manner, speech and voice, social ease, tact, tolerance and similar qualities; ability to apply principles of democratic behavior; understanding of and ability to use desirable procedures in squad management and organization; adherence to standards of professional ethics.

He should assist in teaching and in rendering service in related areas in the curriculum based on: understanding the responsibility of interscholastic athletics in the total school-community health program and the opportunities which the coach has in the area of health instruction through athletics; ability to render emergency first aid; ability to maintain in a safe and healthful environment for pupils engaging in the interscholastic athletic program.

The athletic coach should be qualified to: administer school and departmental policies; maintain appropriate discipline; promote and maintain desirable teacher-student relations; participate in or conduct meetings, to cooperatively establish objectives, policies and procedures; cooperate closely with the school administration.

He should supervise the special care of shower-locker room suites, gymnasiums, and athletic fields; check periodically and regularly on safety condition of all equipment and facilities; supervise equipment room personnel; provide adequate care and recommend the repair of athletic equipment and supplies.

He should understand legal responsibilities: recognize hazardous situations and what constitutes negligence; establish and maintain suitable safety regulations for all areas and participants; teach safety techniques in all activities; refer all accident cases properly to school authorities.

The athletic coach should also be qualified to assume and maintain responsibilities as a member of the school faculty by: participating actively in faculty meetings; appreciate the values and importance of professional growth; maintain membership in representative professional education organizations.

Conclusions

In general, school superintendents and coaches were in close agreement in regard to the desirability of the coaching competencies listed on the questionnaire. In view of the fact that 170 coaches had no training in the field of physical education, it is doubtful that their preparation for coaching has been adequate.

Recommendations

All persons coaching inter-scholastic athletics in Minnesota should hold at least a minor in physical education. Teacher education institutions in this state should use the results

of this study as a guide in the development of programs for the professional preparation of physical education teachers and athletic coaches.

Results

At its regularly scheduled meeting November 14, 1956, the Minnesota State Board of Education unanimously adopted a regulation, requiring that all coaches of inter-scholastic football, basketball, baseball, hockey, wrestling, and track and field, shall possess as a minimum qualification a minor in physical education before they will be certified in Minnesota. This regulation will become effective during the school year 1959-60 to afford undergraduates who wish to coach an opportunity of meeting the requirement before graduation.

What the High School Senior Knows About Health

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IN 1953 the Health Section of the New Jersey Association of Health and Physical Education undertook a project to find out what the high school senior knows about health.

The Shaw-Troyer Health Knowledge and Application Test was selected for use in this study. The test was originally validated empirically from health texts and syllabi and reviewed by physicians, nurses, nutritionists, biologists, and health education teachers. The authors obtained a reliability coefficient of .92. Norms previously established on a nation-wide basis were used in the present investigation for purposes of comparison.

The purposes of this study were: 1. To determine the health knowledge of senior students in the secondary schools of New Jersey; 2. To discover the degree to which students have gained an ability to use that health knowledge; and 3. To discover the strengths and weaknesses in topical areas of health instruction.

A random sampling of schools from 21 counties of New Jersey were invited to participate in the study. Twenty schools from 12 counties accepted. They included urban and rural schools, schools located in industrial and agricultural areas, as well as schools in good and poor economic areas.

Each of the participating schools was asked to administer the test to a random group of students. The total number of students tested was 1,171 (545 male students and 626 female students).

Findings of the Study

The study revealed that the average score for the 20 schools was 67.45 (51st—60th percentile). The highest average score attained by a school was 74.42 (71st—80th percentile). The lowest was 62.16 (31st—40th percentile).

It was found that the boys' mean score was 65.5 which placed them in the 41st—50th percentile, while the girls' mean score was 68.5 which fell in the 51st—60th percentile.

An attempt was made to determine the relationship which existed between health knowledge and the application of health knowledge. The Shaw-Troyer Test was designed to measure both factors.

The coefficient of correlation (product-moment method[1]) between the health knowledge test scores and the application of health knowledge test scores was found to be .42.

Finally, the data were analyzed on a topical area basis as a means of finding out those aspects of health instruction which needed greater emphasis. For example, there were 25 questions dealing with mental health and among the 1,171 students a total number

[1]Henry E. Garrett, *Statistics in Psychology and Education.* New York: Longmans, Green and Co., 1947, pp. 282-288.

of incorrect answers or questions not answered of 8,994, netting an arithmetic average of 359.76 or 360 times per question. The greatest difficulty was experienced in a group of 30 questions dealing with safety and first aid, with an average of 419 per question.

Conclusions

The results of this study appear to justify the following conclusions:

1. There is a moderate range of mean scores among the 20 schools participating in the study. On the basis of national norms the range of percentile values extended from approximately the 35th to the 75th percentile. The mean score of the 20 schools is 67, which falls in the 50th percentile. The girls are slightly ahead of the boys in health knowledge.

2. Apparently there is only a moderate correlation (.42) between health knowledge and the application of knowledge.

3. Concerning the specific areas of health instruction, the students scored in health knowledge (with increasing order of difficulty) as follows: (a) mental health, (b) health in the home, school and community, (c) nutrition, and (d) safety and first aid.

Research Abstracts

Prepared by the Research Abstracts Committee of the National Council of the Research Section, PAUL A. HUNSICKER, Chairman

Anthropometry

34. GARN, STANLEY M., and EDWARD L. GARMAN. Comparison of pinch-caliper and teleroentgenogrammetric measurements of subcutaneous fat. *Human Biology*, **28**: 4: 407-413 (Dec. 1956).

Roentgenogrammetric and pinch-caliper measurements of the fat-plus-skin thickness at the lower thoracic region at the mid-axillary line were compared. For 65 college male students, age 21 and 22, the correlation between the two sets of measurements was .88. While the two distributions were of comparable form and degree of skewness, the "double skinfolds" averaged 70% of their calculated true value, indicating 30% reduction due to compression under a total force of 300 grams.—*D. B. Van Dalen.*

Education

35. GELLERT, ELIZABETH. Systematic observation: a method in child study. *Harvard Educ. Review*, **25**: 179-195. (1955).

A detailed exposition of the major procedures and problems involved in carrying out observational studies of young children is presented. Points touched upon are: (1) the definition of behavioral dimensions selected for study; (2) the selection of a recording scheme; (3) the development of a system for classifying observed behavior; (4) the choice of behavior units for quantification; (5) the reliability of observational data; (6) the problem of observer effect; (7) the validity of measures of behavior derived from observation. Areas and behavior dimensions that have served as subjects for observational research are examined critically.—*Psychological Abstracts.*

36. HARTSHORN, ELIZABETH. A comparison of certain aspects of student leadership and non-leadership: significant differences on four psychometric tests. *J. Educ. Res.*, **49**: 7 (Mar. 1956).

One hundred and twenty-six students attending the University of California at Los Angeles were given the following tests: Minnesota Multiphasic Personality Inventory, Minnesota T-S-E inventory, Allport-Vernon Study of Values, American Council on Education Psychological Examination for College Freshmen.

On the Social Introversion-Extroversion Scale (MT-S-E Inventory), leaders and members made first and second highest scores. On the Theoretical Scale (Allport-Vernon Study of Values), non-members, members, and leaders scored respectively first, second, and third. On the Economic Scale, members and leaders differed from non-members. On the Political Scale, the leaders and members made higher scores than did the non-members—*Edna Willis.*

37. JOHNSON, ORVAL G. The teacher and the withdrawn child. *Mental Hygiene*, **40**: 529-34 (Oct. 1956).

The author is a school psychologist who sent a questionnaire to all first and second grade teachers in the Jackson (Mich.) public schools asking them to describe specific techniques they used to bring withdrawn children into the group. The author found no significant differences in age, experience, or performance ratings between the 32 teachers who responded and the 40 who did not. The responding group did have slightly more formal training. More than half of the suggestions were concerned with developing the child's confidence in himself. The other suggestions fell into other general categories

such as "manipulate the environment to encourage the child's contact with his peers," and "wean the child gently away from withdrawal and toward participation." The teacher of physical education will see numerous opportunities in her area to implement these objectives.—*Bruce L. Bennett.*

38. WILLIAMS, LLOYD P. Democracy and hierarchy: a profile of faculty meetings in department "X." *J. of Educ. Sociology*, **30**: 168-72 (Dec. 1956).

This is a critical study of faculty participation in three consecutive departmental meetings by a former member of the department. The author attempted to test the frequent declaration by some members of the staff that the department was very democratic. The department consisted of 20 professors, 8 associate professors, 4 assistant professors, and 22 instructors.

Principal conclusions from a frequency tabulation of participation were that professors and associate professors dominated the meetings, and a minority within these two ranks did most of the talking. Assistant professors and instructors were passive onlookers. The author also draw certain analytical conclusions from other observations. For example, he notes the absence of any dissenting votes on parliamentary motions which suggests that they were either unimportant or that intangible restraints were operative. He comments also that department meetings are sometimes used to approve "democratically and formally" decisions that have already been made by the dominant group and administration. He concludes that the democracy of this department is in essence "specious, presumptive, and partial."—*Bruce L. Bennett.*

Health

39. BLOOMQUIST, EDWARD R. Appendicitis. *Today's Health*, **34**: 27, 52, 54 (Sept. 1956).

The appendix is a small worm-shaped structure at beginning of the large bowel which is essentially free to rotate through an arc of 360 degrees. Acute appendicitis may strike anywhere between the liver and the pelvis but is usually in the lower-right quadrant. Symptoms include tenderness of the muscles over the diseased part, a lack of appetite, and one is usually aware of the lack of urge to defecate, although this is not always true. If sudden persistent abdominal pain appears, there are four important rules to follow: (1) Go to bed (less chance of spreading infection); (2) Call your doctor; (3) If pain is severe, place an ice bag on the abdomen (localizes the infection and retards its progress); (4) Never take a laxative for undiagnosed abdominal pain.—*J. Grove Wolf.*

40. CELLER, JUDITH. Helpless—not hopeless. *Mental Hygiene*, **40**: 535-50 (Oct. 1956).

Those in the area of adapted physical education cannot afford to overlook this autobiographical story of a person with severe cerebral palsy. The account of her relationships with other people from childhood to adulthood is a moving story of joy and sorrow and a constant struggle for personal adjustment to her environment. It is a significant and detailed case study which defies summarization and needs full reading. It is a story which will help any teacher in working with atypical students.—*Bruce L. Bennett.*

41. CORCORAN, A. C., and I. H. PAGE. Low blood pressure. *Today's Health*, **34**: 18-22 (July 1956).

Blood pressure is the pressure in the large arteries that carry blood from the heart to the rest of the body. It is measured in terms of the height to which the pressure in the blood vessels will raise a column of mercury. Most insurance companies place the normal upper limit at about 150/100 millimeters of mercury. Low blood pressure may be due to chronic infection, anemia, or the like. If blood pressure is really low, the first thing one should do is to get in good physical condition by a graduated program of regular exercise. A person with low blood pressure may need more rest than other people.—*J. Grove Wolf.*

42. KLATSKY, MEYER. The incidence of six anomalies of the teeth and jaws. *Human Biology*, **28**: 4: 420-428. (Dec. 1956).

The incidence of six anomalies which lend themselves most to study by means of skull examination were studied. A total of 8,328 skulls belonging to 25 geographically arranged groups were investigated. Torus palatinus was found in 18 of these groups, both ancient and modern, totalling 482 palates. Torus mandibularis was found in 89 mandibles of 11 groups, mostly non-Europeans. The occurrence of supernumerary teeth was limited to 14 groups, totalling 41 teeth. A total of 947 naturally missing teeth, mostly third molars, were found among all the 25 groups. Reduced teeth were found in 20 groups, totaling 129 teeth. One hundred fifty-seven impacted teeth, mostly third molars and canines, were found in 19 groups, affecting Europeans and non-Europeans alike.—*D. B. Van Dalen.*

43. KRALJ-CERCEK, LEA. The influence of food, body build, and social origin on the age of menarche. *Human Biology*, **28**: 4: 393-406 (Dec. 1956).

The mean age at menarche of 233 secondary school girls of Slovenia (Styria) was 13.61 ± 0.83 years. It ranged from 10.0 to 17.25 years. The mean age of menarche of 52 girls from the Island of Susak in Northern Adriatic was 13.94 ± 0.17 years. Girls who ate predominantly proteinous foods had their menarche sooner than girls who ate mixed foods, whereas those who ate carbohydratic food menstruated latest. The Slovenian girls had their menarche from 0.1 to 0.7 months earlier than the Susak girls. Body build also had an influence on menarche. Girls of the pyknic type (12.93 ± 0.222) menstruated earlier than girls of the medium type (13.5 ± 0.104), whereas, the linear type had the latest menarche (14.61 ± 0.134). Girls of the good social origin (13.28 ± 0.134) had their menarche first, then the intermediate (13.71 ± 0.104), and then the poor group, (14.2 ± 0.282).—*D. B. Van Dalen.*

44. RATCLIFF, J. D. Muscles, how they work and how to use them. *Today's Health*, **34**: 36-40 (Jan. 1956).

More than half of the human body is muscle—muscles are the body's "furnace" supplying nearly all our internal heat. There are three types of muscles in the human body: striated muscles that propel us when we walk, smooth muscles which control such involuntary actions as the churning of intestines during digestion, and cardiac muscle found in the heart. Two proteins are mainly responsible for muscular contraction—actin and myosin. Actomyosin is the muscular "engine" while the fuel is a remarkable chemical substance, adenosine triphosphate. Exercise plays nearly as important a role as food in muscle nutrition. Several studies have shown the beneficial results of exercise, particularly with the heart muscle.—*J. Grove Wolf.*

45. SALK, JONAS E., M.D. Poliomyelitis vaccination in the fall of 1956, *Amer. J. of Public Health*, **47**: 1-18 (Nov. -Jan. 1957).

This is a report on the degree of vaccine effectiveness and persistence of immunity. The principal question is whether or not the development of effective and durable immunity to a virus disease is acquired only through the experience of infection or whether the immunity can be induced by a non-living antigen. It appears that immunity to paralysis is mediated either through the presence of antibody in the circulating blood, or through the rapid reappearance of antibody triggered by exposure of a hyperactive immunologic mechanism. Vaccine effectiveness depends on the level of potency. —*Joseph E. Lantagne.*

46. YANKSAVER, ALFRED, M.D., and RUTH LAWRENCE. A study of periodic school medical examination, *Amer. Medical J. of Public Health*, **46**: 12: 1553-1562 (Dec. 1956).

The objective is to evaluate the need for periodic medical examinations in school. This study was done in Rochester covering 15% first grade pupils. Then follow-up exams were given during the next three years to determine the value of annual exams. During the next three years, only 14% of the children developed adverse conditions not previously detected. About one-half of these conditions were under care. The end result gave a

case-finding yield of one child per every 251 examinations. Periodic health examinations in the first four grades are of little value from a case-finding standpoint.—*Joseph Lantagne.*

Physiology

47. Bannister, R. G. Muscular effort. *Brit. Med. Bull.*, **12**: 3: 222-225. (Sept. 1956).

The muscular effort of running is limited by two factors. The first is the maximal contractile activity of muscle, which limits speed in sprinting. The second is the rate of supply of oxygen and metabolites to muscles and the removal of the products of muscular contraction. In "steady state" running, efficient oxygen transport to muscles is achieved by a physiological integration causing increases of pulmonary oxygen intake and transfer, cardiac output, and muscle blood flow. Yet in "all-out" running in which adequate carbohydrate is available, oxygen supply fails to keep pace with requirements and there is evidence that the arterial pO_2 falls. Oxygen supply is the weak link. But it seems academic to argue whether this failure occurs because the alveolar-arterial gradient for oxygen is increased or because blood is not circulating fast enough. The muscular effort in long-distance running appears to be limited by cardio-respiratory failure as a whole and not by premature failure of any single part of the integration.

Yet the difference between athletes lies not entirely in differences of cardiac output or diffusion capacity; it lies in their capacity for mental excitement, which brings with it an ability to overcome or ignore the discomfort—even pain—in muscles and the brain which is probably caused by ischemia and the consequent changes of blood lactate concentration and pH. Though physiology may indicate respiratory and circulatory limits to muscular effort, psychological and other factors beyond the ken of physiology set the razor's edge of defeat or victory and determine how closely an athlete approaches the absolute limits of performance.—*Paul Hunsicker.*

48. Fregly, Melvin J. and Cynthia S. Cook. Effects of experimental hypertension and of aging on the spontaneous running activity of rats. *Am. Journal of Physiology*, 187—293-296 (Nov. 1956).

Rats were used to test the result of bilateral encapsulation of the kidney on their normal spontaneous running activity. Activities of the group operated on was greater at 22 and 52 days postoperation until the rising blood pressure leveled off then the control and experimental group levels were the same. After the blood pressure reached a new high level there was no evidence of a relationship between activity and blood pressure. The level of activity always decreased with age.—*E. Michael.*

49. Katz, B., M.D. The role of the cell membrane in muscular activity, *Brit. Med. Bull.*, **12**: 3: 210-213 (Sept. 1956).

The function of the muscle membrane is to receive the stimulus from the nerve and transmit it to the contractile substance. How excitation is passed on from the surface to the interior of the muscle fiber has so far eluded clarification. But the mechanisms of reception of the signal and of its distribution along the fiber surface are now fairly well understood. A special situation exists at the myoneural junction where a large postsynaptic cell is triggered into activity by an impulse arriving in small presynaptic axon branches. Direct local-circuit transmission comes to a halt at this point and is replaced by chemical transmitter action. Acetylocholine is released, in discrete quantal parcels, from the nerve-endings and, acting on receptors in the external surface of the end-plate membrane, causes a large increase of permeability to Na, K, and possibly other free ions. This gives rise to local currents of sufficient intensity to depolarize and excite the surrounding area of the muscle fiber and so initiates a new propagating impulse.—*Paul Hunsicker.*

50. Merton, P. A. Problems of muscular fatigue. *Brit. Med. Bull.*, **12**: 3: 219-221 (Sept. 1956).

The limit of muscular endurance may be nearer than is imagined even in light skilled tasks. Muscular fatigue is likely to be of importance in causing a sudden breakdown of

performances when working near the limits of reserve. The present indications are that it will not be of significance at other times, owing, perhaps, to the excellence of the muscle's proprioceptive servo-control, which compensates automatically for fatigue. It is difficult to guess, without experiment, which tasks do strain the reserves of the muscles they use, for until the reserves are gone there is little or no subjective sense of fatigue. Nor do there appear to be relevant observations in the literature; in most work on fatigue of skilled movements (e.g., Bartlett, 1953) little attention has been given to the muscular factor.—*Paul Hunsicker.*

51. Nahas, Gabriel G. Heart rate during short periods of apnea in curarized dogs. *Am. Journal of Physiology*, **187**: 302-306 (Nov. 1956).

Eleven dogs were given intravenous injections of d-tubocuraine to arrest ventilation. Mechanical breathing was installed and heart rate, blood pressure, and blood samples were studied. A significant bradycardia was seen after 60 seconds of apnea. The heart rate fell 70% in 90 seconds while the systemic pressure rose 5.6 mm Hg and the central venous pressure fell 2.1 mm Hg. Expiratory pCo_2 increased 16 mm Hg and blood arterial ph dropped .02. The indication was that respiratory acidosis was the main factor responsible for the brady-cardia. These same results occurred when bilateral cervical vagotomy was done and after moderate hypoxia.—*E. Michael.*

52. Zucker, Theodore Frederick, *et al.* Antibody formation and natural resistance in nutritional deficiencies. *J. Nutrition*, **59**: 2 (June 1956).

A vaccine prepared from killed cultures of *Corynebacterium kutscheri*, strain 197, has been administered to rats with various dietary deficiencies: calories, thiamine, pyridoxine, and pantothenic acid. With deficiencies of calories or thiamine, there is no significant reduction in ability to form agglutinins. No detectable agglutinins are formed in pyridoxine deficiency. In pantothenate deficiency, some animals lost their ability to form agglutinins while this capacity is impaired in others, resulting in a mean value between those for deficiencies of thiamine and pyridoxine. Ability to make agglutinins is entirely unrelated to the degree of resistance to the live organism shown by rats on these various regimes. Therefore it is concluded that the resistance of the normal rat, which is lost in pantothenate deficiency, does not rest upon ability to form antibodies as typified by agglutinins.—*The Wistar Institute.*

Miscellaneous

53. Battig, W. F. Transfer from verbal pretraining to motor performance as a function of motor task complexity. *J. of Exp. Psych.*, **51**: 6 (June 1956).

Twelve groups of 20 subjects were used to study the effects of verbal pretraining upon motor tasks of different levels of complexity. It was found that the amount of positive transfer from verbal pretraining decreased as the complexity of the motor task increased. The task was one of finger-positioning, the complexity of which was increased by increasing the number of fingers used.—*Edna Willis.*

54. Greenspoon, J. and S. Foreman. Effect of delay of knowledge of results on learning a motor task. *J. Exp. Psych.*, **51**: 3 (March 1956).

Five groups of eight subjects each were used to study the effect of the knowledge of results upon learning to draw a three-inch line while blindfolded. Results indicate that increasing the length of time between the performance of the task and receiving information about their accuracy reduced the subjects rate of learning. A delay of 30 seconds was found to be superior to receiving no information.—*Edna Willis.*

55. Scientific American Editors. The physics and chemistry of life. New York: Simon and Schuster, 1955.

This collection of 18 articles is reprinted from the *Scientific American* and deals with a variety of biochemical problems of living matter. One group of three articles deals with muscle and nerve action.—*Psychological Abstracts.*

Guide to Authors

IN LINE WITH the over-all goal of making Association publications yield the greatest value to the individual and the profession, the following is a guide for the preparation of manuscripts for the *Research Quarterly*, recognizing general techniques employed by research publications.

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Since three members of the Board of Associate Editors review an article, it is requested that three clear copies of the manuscript be submitted in order to facilitate reviewing. A fourth copy of the article should be retained.

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Notes on minor research and on apparatus, *objective* critical comments, and summaries of status suveys will be printed in the Notes and Comments section. Note that simple status surveys are no longer acceptable as regular *Quarterly* articles, by decision of the Research Council. Such studies will therefore be published in brief form (300-500 words) under Notes and Comments.

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Footnotes are not to be used for references or literature citations. They are rather used for the purpose of acknowledgment, special explanation, supplementary information, etc. (*See examples below.*)

Type footnotes (if any) on separate sheets, as many footnotes as convenient being written on a sheet. Footnotes should be numbered from 1 up for each article; a corresponding numeral appearing in the text. Asterisks should not be used.

Examples of Footnotes:

[1] This study was made under the direction of Dr. Arthur T. Slater-Hammel in the Research Laboratories, School of Health, Physical Education, and Recreation, Indiana University, Bloomington, Indiana.

[2] All measurements of the hand were recorded in centimeters and height was recorded in inches. The hand measurements were taken by Everett and reliability coefficients of above .90 were found for each measurement used in the study.

[3] For their wholehearted co-operation in facilitating collection of the data, special gratitude is extended to Superintendent Clarence Hines and the 1950-51 principals of the Adams, Condon, Edison, Francis Willare, Harris, Howard, Lincoln, River Road, and Whiteaker schools.

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Citations of literature should be segregated alphabetically by author's last name at the end of each article, under the caption of "REFERENCES." *Do not treat them as footnotes.* (*See above.*)

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A uniform style should be maintained in writing citations. Do not enclose titles of chapters and articles in quotation marks. Italicize (underscore in manuscript) names of books and periodicals, bulletins, etc. (*See examples below.*)

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Examples of References Appearing at End of Article:

1. American Association for Health, Physical Education, and Recreation. Suggested platforms for health education. *Journal of the American Association for Health-Physical Education-Recreation*, **18**:436 (Sept. 1947).
2. American Association of School Administrators. *Health in Schools.* Revised edition. Washington, D. C.: the Association, a department of the National Education Association. pp. 266-7.

3. DEAVER, G. G., Exercise and heart disease. *Research Quarterly*, **26**: 24-34, 1939.
4. OGDEN, JEAN, and JESS OGDEN. *Small Communities in Action.* New York: Harper & Brothers, 1946.
5. POTTER, JOHN NICHOLAS. *Physical Fitness of Junior High School Boys.* Unpublished Master's thesis, University of California, Berkeley, 1942.

Tabular Matter

Each table should have a descriptive heading and should be specifically referred to in the text by number, *e.g.*, "Table 10," etc., never as "the above table" or "the following table." Number tables from 1 up for the entire manuscript, using Arabic numerals. Do not duplicate data by giving it in *both* tables and graphs.

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Illustrative material is of two types: pen and ink drawings, which are reproduced by the line engraving process; and photographs, wash drawings, stipple drawings (in short, anything containing shading), which are reproduced by the halftone process.

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Standard abbreviations should be used whenever the weights and measurements are used with figures, i.e., 10 kg., 6.25 cc., etc. The forms to be used (for both singular and plural) are: ft., ft.-lb., ft/sec, in., yd., min., hr., sq. ft., sq. in., rpm. *Gram* should be spelled out in all cases to avoid possible confusion with *grain;* also spell out *mile.* All obscure and ambiguous abbreviations should be avoided. Symbols used should follow the notation listed in *Research Methods* (AAHPER), pp. 518-20 and 522-25. Most common are:

M = mean	r = Pearson correlation
Mdn = median	r_{bis} = biserial correlation
N = number of individuals	r_{11} = reliability coefficient
n = number of measurements	χ^2 = chi square
σ = standard deviation	F = variance ratio
σ_M = standard error of mean	t = Student (Fisher) t ratio

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